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THE PRODUCT OF THE EUREKA TEMPERED COPPER COMPANY.

[*Report of the Committee on Science and the Arts.*]

[No. 1,491.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, October 1, 1890.

The sub-committee appointed to examine and report upon application No. 1,491, made by the Eureka Tempered Copper Company, of North East, Erie County, Pa., dated April 21, 1890, and supplemented by their letter of August 7, 1890, beg leave to report:

That in the applications, as above, the applicants claim to possess processes invented by Almer Thomas and Luzerne Merket, of North East, Pa., in the first place, for casting pure copper without alloys, so as to make castings sound and free from blow-holes; and, in the second place, for hardening copper (after casting) without destroying its fibre or impairing its usefulness for electrical or other purposes. They also claim that no alloys are added to the cop-

per, and that the chemical composition of the castings is substantially the same as that of the ingot copper from which it was made.

As the processes in question (not having been patented) have not been described to your committee, we have, of necessity, confined our examination to the products of the applicants.

This examination has been made in three ways:

(1) Chemical analyses have been made of both the untempered and the tempered copper.

(2) Physical tests have been made, including tensile, transverse, compression and torsion tests of the untempered and of the tempered copper.

(3) Circulars have been sent to over 100 establishments in the United States and Canada, using tempered copper, asking for the results of their use of same, with any expression of opinion that they may see fit to give.

The results of these examinations have been made as follows:

(1) Chemical analysis.

Dr. F. A. Genth, of this city, reports two sets of analyses of these coppers as follows:

	(1) *Pig Copper.* *Per Cent.*	(2) *Edge Pieces.* *Per Cent.*	(3) *Castings.* *Per Cent.*
Silver,	0·096	0·053	0·095
Copper,	99·890	99·961	99·914
Tin,	trace	0·045	0·094
Lead,	trace	trace	trace
Iron,	0·056	0·069	0·056
	100·042	100·128	100·159

	(1) *Not Tempered.* *Per Cent.*	(2) *Tempered.* *Per Cent.*
Silver,	0·026	0·025
Copper,	99·930	99·981
Tin,	none	none
Zinc,	none	none
Iron,	0·082	0·088
Aluminium,	none	none
Arsenic,	0·046	0·042
Phosphorus,	0·017	0·018
	100·101	100·154

The last two analyses were made from the same bar. No. 1 not tempered being made from the bar as cast by the processes of the applicants, but untempered; and No. 2 tempered being made after that bar had been tempered. It should also be mentioned that these same bars were used in the tensile tests described later on.

The above chemical examination shows that the examples are commercially pure copper, and thus substantiates the statement made to that effect by the applicants.

The principal tests were made by Mr. Tinius Olsen, of this city.

The diagrams, as made by his machine, are annexed to this report. The results, in figures, are also given on these diagrams. It is interesting to note how the tempered copper compares with the untempered copper in the first place, and in the second place how our tests compare with tests of ordinary commercial copper. It will be observed that the difference between the tempered and untempered copper is not very great; although, speaking generally the difference is in favor of the tempered samples.

As compared with such tests of ordinary commercial copper as the committee have been able to find, the difference is more marked. For example:

Untempered pieces broke at a strain per square inch of—

	Pounds.
(1),	23,180
(2),	24,410
Mean,	23,795

and the tempered pieces broke at a strain per square inch of—

	Pounds.
(1),	25,800
(2),	27,860
Mean,	26,830

It should be mentioned that there was a similar flaw in all of the above samples (due to piping from the shrinkage), which ran longitudinally on the edge of the pieces. Most of this faulty part had been removed when the samples

RECORD OF TESTS OF TEMPERED AND UNTEMPERED COPPER, MADE FOR THE COMMITTEE ON SCIENCE AND THE ARTS, AT THE TESTING ROOMS OF TINIUS OLSEN & CO., PHILADELPHIA.

Marked.		Size.	Area in Square Inches.	Broke at Lbs.	Strain per Square Inch in Lbs.	Limit of Elasticity in Lbs.	Limit of Elasticity per Square Inch in Lbs.	Elongation in Inches.	Elongation per Cent. of Original Length.	Area of Reduced Section in Sq. In.	Reduction per Cent. of Original Section.	Memoranda.
Tensile, . .	B Tempered, ...	·858 ·752 ·851	·6452	16,650	25,800	7,400	11,460	·72	18·0	·4725	26·7	
	A Tempered, ...	·753 ·853	·6408	17,855	27,860	7,000	10,920	·94	23·5	·4060	36·6	
	B Untempered, . . .	·755 ·86	·6440	14,930	23,180	6,550	10 170	·84	21·0	·4095	36·6	
	A Untempered, . . .	·755	·6493	15,850	24,410	6,550	10,080	·90	22·5	·420	35·7	
Compression,	C Tempered, ...	·935 × ·938 1″ high	·8770	49,150	56,040	13,000	14,820	·28	28·0			
	E Tempered, ...	·938 × ·934 1·002″ high	·8761	46,500	53,070	12,400	14,150	·269	26·8			
	C Untempered, . . .	·935 × ·937 1·002″ high	·8761	41,310	47,150	12,000	13,690	·275	27·4			
	E Untempered, . . .	·935 × ·939 1″ high	·8779	45,300	51,600	14,000	15,940	·276	27·6			
Transverse,	D Tempered, ...	·938 ·941	·8826	Commenced permanent deflection at 820.				Deflect, 1″ at a load of 1,380 lbs.				Strain applied in centre of specimen on supports 12″ apart.
	F Untempered, . . .	·94 ·942	·8854	Commenced permanent deflection at 500.				Deflect, 1″ at a load of 1,200 lbs.				
Torsion, . .	C Tempered, ...	·937	·6895	Yielded permanently at 120 lbs. Maximum load, 588 lbs. Ruptured after being twisted, 391°.								Measuring heads 2″ apart and strain recorded on 12″ leverage.
	E Untempered, . . .	·937	·6895	Yielded permanently at 106 lbs. Maximum load, 557 lbs. Ruptured after being twisted, 600°.								

were cut in two lengthwise (for the purpose of having one-half of the piece sent to the applicants to be tempered). But a sample perfectly free from this piping would probably have given results somewhat higher than the above.

To compare the above figures with those of ordinary commercial copper, we submit herewith the results made on cast copper, by the United States Testing Board, and given in their report on *Iron, Steel and other Metals.* (Washington: Government Printing Office, 1878.)

Marks.	*Greatest Stress per Sq. In.*
1A,	14,180
1B,	11,340
30A,	29,200
30B,	26,400
51A,	14,546
51B,	20,440
52A,	16,940
52B,	21,600
53A,	18,800
53B,	9,200
57A,	26,000
57B,	29,820
Mean,	19,872 pounds per sq. in.

It thus appears that the untempered and the tempered copper have twenty per cent. and thirty-five per cent. greater tensile strength, respectively, than the average, as shown by the Government report.

In regard to the compression results (see diagrams herewith) are—

	Limit of Elasticity in Pounds.
Untempered (1),	12,000
(2),	14,000
Mean,	13,000
Tempered (1),	13,000
(2),	12,400
Mean,	12,700

The elastic limit of ordinary copper, according to Unwin (*Machine Designing*, D. Appleton & Co., 1877, p. 24) is 3,900

pounds, showing a great difference in favor of the samples tested by us.

As no figures for commercial copper, showing its tension and transverse strength, are available to the committee, we have been unable to make any comparisons showing the relative figures in these respects.

The result of the correspondence between the committee and various manufacturers, electric light companies, millwrights and other establishments, has been as follows:

In all fifty-three letters were received, in which a definite opinion was expressed. Of these, five were to the effect that the writer was unable to see any difference between the tempered copper and other metals and alloys. Eight parties had tried the copper, experimentally, for certain purposes, for which it evidently was unfit, such as for bits for rock drilling; as a substitute for tempered steel; for ammonia pump rods; for cauterization of blemishes in the limbs of horses; for nozzles for locomotive injectors when using certain saline waters, and so on.

Six expressed the opinion that the claims of the applicants were not substantiated by the experience of the writers.

Thirty-four expressed opinions, based upon their experiences, which were highly favorable to the tempered copper. Thus, it was stated that for bearings on coal-mining machinery it lasts much longer than any other metal before used; that it outlasts from three to four times the old style of commutator copper bars or brushes; very satisfactory for brasses on engine rods; bearings on dynamos run very cool and require but little lubrication; gives entire satisfaction on bearings of three threshing engines; in wrist-pin boxes and in cross-head; as step in gauge lathe, between end of spindle and set-screw is superior to hardened steel, brass, rawhide or wood, all of which were previously tried; very uniform in hardness and remarkably free from blow-holes; gave good results as a driving pinion in gear work; stood up well as armature bearing in street-car motors (a trying test), in small bearings, where the brass bearings would not last over sixty days the tempered copper has been nearly in a year, and is apparently in as good a condition as when first

put in. Many other extracts could be given, particularly from parties endorsing the copper for commutator brushes and segments, to which it seems particularly well adapted.

A number of specimens of castings are presented with this report, showing high excellence in quality and uniformity. Mechanical examination bears out the statements of the applicants as to the purity of their metal.

We believe that the claims of the applicants are substantiated by the experience of the majority of the parties using their copper, and also by our own investigations. We are of the opinion that the Eureka Tempered Copper Company has made a decided step in advance in the preparation of copper for many industrial uses, and we recommend the award to Almer Thomas and Luzerne Merket, of the JOHN SCOTT LEGACY MEDAL AND PREMIUM.

H. PEMBERTON, JR., *Chairman,*
LUTHER L. CHENEY,
NATHAN H. EDGERTON,
C. HANFORD HENDERSON,
RICHARD D. BAKER,
F. LYNWOOD GARRISON.

Adopted November 5, 1890.

H. W. SPANGLER,
Chairman of the Committee on Science and the Arts.

MANUFACTURE OF TIN-PLATE.

By F. Lynwood Garrison, Philadelphia, Pa.

[*Read at the Stated Meeting of the Franklin Institute, held Wednesday, November 19, 1890.*]

The process of manufacturing tin-plate, and indeed the character of the product appear to be something of a popular mystery which the public, in this country at least, is very slow in comprehending. Anything from a roof to a cup which happens to be made of tin-plate is called tin. It was gravely stated in a Western paper, some few months ago, that tin-plates were being extensively mined in the Black Hills, Dakota. Such ignorance is truly startling, and it would seem about time the public was informed that what is usually called tin, is simply sheet iron coated with from two to five per cent. of that metal, and that few or no articles of commerce are made of the pure metallic tin itself.*

When the iron sheets are coated with an alloy of tin, and from twenty-five to sixty per cent. lead, they are known as terne-plates, and have a dull leady appearance as compared with bright lustrous tin-plate. Terne-plates are usually used for roofing purposes, and are not infrequently sold as tin-plate pure and simple. When used for purposes other than the preservation or preparation of foods, terne-plate usually fulfils its requirements quite as well as tin-plate, and has the great advantage of cheapness.

History.—The manufacture of tin-plates seems to have originated in Northern Germany, but the particular place and year in which it was commenced are unknown.

Flower† states that it has been very clearly ascertained

* There seems to be a similar misconception as regards galvanized iron, which is simply iron coated with metallic zinc by being immersed in a molten bath of that metal. There does not seem to be any galvanic action whatsoever taking place during the operation, it is an alloying of the iron and zinc pure and simple.

† *History of Tin and Tin-plates*, P. W. Flower. George Bell & Sons: London, 1880.

that in 1620 the trade had already existed for many years in Bohemia. "In that year a knowledge of the manufacture was sought and obtained from Bohemia by the then Duke of Saxony, who immediately commenced the manufacture in his own territories, and it was from Saxony that the secret came to England in the year 1670." Works were first established at Pontypool, but, in consequence of certain difficulties were subsequently abandoned and neglected for a period of fifty years, and it was not until 1720, that the manufacture of tin-plate can be said to have been carried on to any extent.

Flower states that there appears to be no mention of the invention in any of the old French, German, or English works on metallurgy, and it seems to be probable that all information relating to this trade was kept very secret with a view to a quiet enjoyment of the monopoly by those who possessed a knowledge of its details. M. de Reaumur, writing in 1725, confirms this idea by saying that the art of making tin-plates was considered Germany's own trade.

The French iron-masters were not behind the English in introducing this industry into their country, the first successful works having been started in Mansvaux, in Alsace, in 1714, several years before the industry was thoroughly established at Pontypool. Two previous unsuccessful attempts were made to establish the industry in France, one at Chenessy, in Franche Comté; and the other at Beaumont la Ferrière, in Nivernois. The successful works started at Mansvaux, in Alsace, were followed by those of Bains, in Lorraine, in 1733; Imphy, near Nevers, in 1745, and Morambeau, in Franche Comté, in 1751.

Works were established near Forsmark, in Sweden, in the year 1739, English tin being imported for the purpose.

After the successful start, at Pontypool, in 1720, the manufacture began to extend itself through Wales, particularly in those places where water-power was available, and where forges already existed for the manufacture of charcoal iron.

From Pontypool it spread to Caerleon and Ponthir, in Monmouthshire, to Ynisgerwn near Neath, and Melin

Griffith near Cardiff, in Glamorganshire, and to Kidwelly and Carmathen Town, in Carmathenshire.*

For the past hundred years the manufacture of tin-plate in Great Britain has gradually increased until now she probably makes ninety per cent of the world's entire production, the rest coming from a few works in Germany and France.

In 1887, Germany produced 16,720 metric tons of tin-plate, basic steel being used almost exclusively for the purpose.†

It is an interesting fact that while the output of metallic tin from the Cornish mines has gradually decreased within the past twenty years (10,200 tons, in 1870, and 9,183 tons, in 1888), the production of tin-plate in Great Britain has increased at an enormous ratio. In 1889, Great Britain exported 430,623 tons, of which 331,312 tons went to the United States; the entire production, in 1889, was about 450,000 tons. The great bulk of the metallic tin consumed in Great Britain in the manufacture of tin-plate is imported —mostly from Malacca Straits and Australia. The same may be said for Germany and France, although some small amounts are still mined in the Zinnwald district in Bohemia.

A brief sketch in this connection of the history of the futile attempts to establish a tin-plate industry in the United States may not be without some melancholy interest to the patriotic American.

The very high prices of tin-plate which prevailed in our markets between 1873 and 1878 induced some enterprising persons to establish a small tin-plate works at Wellsville, O., in 1873. The quality of the plates made at these works was said to be excellent.‡ Between 1873 and 1875, tin-plates were also made to a limited extent, at Leechburgh, Pa. Owing to the fall in prices, in 1875, both of these works were obliged to shut down. In the meantime somewhat more

* Flower's *History of Tin and Tin-plates.* London, 1880.

† *Annual Report of American Iron and Steel Association,* 1890, p. 96.

‡ *A Treatise upon Tin-plate Manufacture in the United States,* by John Jarrett, p. 5.

extensive works were built at Demmler near Pittsburgh, Pa., and put in operation early in 1875. The career of these works as such was, however, short-lived, and since they were shut down there does not appear to have been a single pound of tin-plate made in the United States for commercial purposes.

For commercial purposes tin-plates are divided into two classes, what are termed charcoal-plates and coke-plates, according as charcoal or coke is used as fuel in the manufacture of the iron bars from which the plates are rolled. At the present time, however, by far the greater part of the plates are made of mild steel, usually open-hearth, either acid or basic. It seems, moreover, that these tinned steel sheets are not sold as such, but as tinned iron.

The iron sheets made with charcoal as fuel, are, as a rule, of much finer quality, and bring a better price than the coke iron or steel sheets.

As the methods used for the conversion of the raw ore or pig into these iron or steel bars belongs more particularly to the metallurgy of iron and steel, they need not be mentioned in this connection.

Rolling the Sheets.—The finished bars used in the manufacture of tin-plates vary in dimensions, according to the size and weight of the sheets required, or the manner of rolling.

After the finished bar has been sheared to the required size, it is heated to redness in a reverberatory furnace, and rolled; again heated, rolled, and doubled; heated a third time, rolled, and again doubled; then heated and rolled a fourth time. Sometimes the heating and rolling is continued six times. The length of the bar should be about an inch more than the width of the sheet to be made, so as to allow margin for shearing; the bar is therefore rolled with its axis parallel to the axis of the rolls.

When the plates leave the rolls they are called "finished," and are known as black plate, then when cool are trimmed and sheared as required.

Percy* states that the yield of black plate varies from

* *Metallurgy of Iron and Steel*, p. 726.

eighty to ninety per cent. of the iron used, the minimum yield being obtained from narrow plates rolled in one length and doubled three times, thus making eight sheets 10 x 14 inches, or doubled three times and rolled in two lengths, making sixteen sheets of 10 x 14 inches. The maximum yield is from wide plates doubled only once, and rolled into two lengths, thus making four sheets.

The more frequently a plate is doubled the greater will be the waste, owing to the larger amount of shearings cut off the extremities.

The weight of the ordinary sheets (lx and lxx, 10 x 14 inches, or 14 x 20 inches), is calculated in the following manner:*

Bars are selected of sufficient weight to produce sixteen sheets of 10 x 14, or eight sheets of 14 x 20 inches. Taking for example, 14 x 20-inch sheets, running 112 sheets per box, we have—

Weight when tinned,	150 pounds.†
Shear-house weight,	135 "

The yield of black plate in this variety is eighty-seven per cent. Then $\frac{135}{0.87}$ pounds $= 155$ pounds, the weight of iron required to produce one box of these plates. As each bar of iron will make eight sheets, fourteen bars would be required for 112 sheets, hence $\frac{155}{14} = 11$ pounds, the weight of one bar necessary to produce eight sheets of two lengths doubled twice. This formula will apply to a box of any weight of the same dimensions rolled in the same manner.

Black Pickling.—The plates are now pickled by being immersed in hot dilute sulphuric acid (one part acid to sixteen water), contained in lead-lined tanks. The sheets are placed on edge in a wooden rack made for the purpose, and the whole immersed in the acid. By means of a suitable mechanical arrangement, the rack holding the sheets is given a regular up-and-down motion, thus maintaining a circulation in the acid bath.

When all the scale or oxide has been dissolved off, the

* Percy's *Metallurgy of Iron and Steel*, p. 725, *et seq.*

† Taking 2,240 pounds to the ton.

rack holding the sheets is immersed, and the whole thoroughly washed several times in fresh water. The pickling and washing are carried on at the same time, and spare cradles are provided for filling and emptying, so that no delay occurs.

First Annealing.—The sheets are then dried, packed in tight annealing boxes or pots and annealed from twelve to twenty-four hours in a reverberatory furnace.

The temperature to which the plates are thus subjected is kept just high enough to prevent their softening to such a degree as to cause them to stick together when cold, *i. e.*, just below a good welding heat. The door of the annealing furnace is made level with the floor, so the annealing boxes can be readily wheeled in on a truck. The object of this annealing is to so soften the sheets that they will readily take a polish when cold rolled in the next operation. If the annealing has been properly done, the sheets come out nearly as soft as lead.

Cold Rolling.—In order to receive a proper coating of tin and possess a fine finish, it is necessary to pass the sheets singly through a series of highly-polished cold rolls. These rolls should be as hard as possible, have a high polish, be heavy, and set in strong solid frames. A well-polished surface saves tin, and is very essential to the good appearance of the finished plate. It might be stated in this connection that mild steel-plates always require less tin to coat them than iron, as the former is denser, and the tin has less opportunity to penetrate into the pores of the metal.

Second Annealing.—After the cold rolling the sheets become more or less harsh, and to remove this they are again annealed in the same way, but at a somewhat lower temperature than the first annealing. Ten hours is usually found sufficient for this purpose.

White Pickling.—The surface of the sheets having become somewhat oxidized by the cold rolling and second annealing, it is necessary to pickle them a second time. In this operation, which is known as the white pickling, a much weaker solution of sulphuric acid is used, or sometimes hydrochloric acid is used instead. The slight coating

of oxide or scale is thus quickly removed, and after being thoroughly washed with water, the sheets are supposed to be ready for the coating of tin. As a matter of fact, however, it is always necessary to examine them very carefully after removal from the annealing pots, and if they are rough and contain small specks or patches of undissolved oxide or scale, they will have to be scoured with sand and perhaps re-pickled.

The careful inspection and selection of the sheets is a most important part of the operation, requiring a considerable degree of skill and experience on the part of the workman. It is always better if the sheets can be inspected and the defective ones picked out at end of each of the several operations.

As the workmen are usually paid by the amount of work done, there is naturally a constant tendency for defective sheets to reach the "tin-man's" hands.

The hands required for each set of pots consists of a tin-man, a wash-man, a grease-boy and three girls, who rub, dust and polish the sheets.

The tin-man (foreman of the set that does the tinning) receives the sheets from the scourer and places them in a trough of water near at hand until he is ready to remove them to the grease-pot.

Grease-pot.—As the sheets are removed from the water trough, they are immediately plunged, sheet by sheet, into what is known as the grease-pot, which is filled with hot palm oil or tallow.

The object of the oil bath is to remove the moisture and to warm the sheet so as to prepare it for tinning.

Tin-pot.—After remaining in the hot grease some time, they are removed in parcels and plunged into the tin-pot containing a bath of molten tin covered with palm oil. Here they are allowed to soak for about twenty minutes, the tin-man constantly opening and re-opening the pack with his tongs, thus enabling the molten tin to get at every part of the surface. As a result of the soaking, the iron (or steel) absorbs a certain amount of tin on or into the surface of the sheets. It seems probable that an alloy is formed by

those portions of the two metals which come in close contact. A very large proportion of the tin is thus absorbed and held between the fibres of the iron, as after the pickling and annealing operations the surface of the iron is in a more or less spongy condition. If the tin were simply mechanically held or absorbed by the fibres or pores of the iron, it should be possible to liquate it out by simply heating the tinned sheet to a temperature slightly above the melting-point of tin—227°·8 C., or 458°·6 F. If we heat the tinned sheet to a temperature sufficient to volatilize the tin, and then examine it with a microscope, we shall find that a considerable part of the tin persistently sticks to the iron, and if we attempt to burn it out we shall burn the iron also. Of course, where there is a thick coating of tin, it is possible to melt off the outer layers that are not in direct contact with the iron.

Wash-pot.—When the sheets have soaked sufficiently, the tin-man removes them from the tin-pot and hands them to the wash-man, who plunges them in parcels into the wash-pot filled with tin, and allows them to remain there, to keep hot, until he is ready to use them. They are then removed in batches and placed upon a flat iron plate, called the hob. With a thick hempen brush in one hand and tongs in the other, the wash-man brushes the two sides of each sheet in order to remove the excess of tin which has collected between them. The wash-pot is generally divided into two compartments, one larger than the other. The sheets are first put into the larger compartment, which contains a better quality of tin than the tin-pot, and, as its temperature is comparatively low, the sheets can be kept in it a considerable length of time without becoming "dry."

To obliterate the marks left by the brush, and to give a polish to the surface, the sheets are dipped, one at a time, into the smaller compartment of the wash-pot.

Patent-pot.—Then without releasing the sheet from the tongs, it is passed between a pair of steel rolls into the "patent-pot." As soon as the sheet has passed through these rolls into the tin below, it is caught, moved along and raised by means of a cradle to meet another pair of rolls revolv-

ing in the surface of the tin bath, thus as one sheet is rolled into the bath of tin another is rolled out. The object of these rolls is to squeeze off the surplus tin and give the sheet a smooth, even surface.

The sheets are now placed in a rack to cool, after which they are taken by women and rubbed with saw-dust or bran to remove the grease, then polished with flannel or buck-skin, and removed to the sorting-room. Here they are very carefully examined and classed according to finish and quality.

The tests of quality are ductility, strength and color; this when in a high degree requires that the iron or steel used shall be of the best quality, and that its subsequent manufacture into sheets and the tinning process through which they go shall be conducted with the greatest care and skill.

Some of the defective sheets, known as "menders," are returned to the tin-house for repair; others, known as "wasters," are sold on the market at a reduced price.

After the finished sheets are counted, they are packed in wooden boxes, which are carefully marked to indicate contents.

The use of the oil or grease is to preserve the tin and iron from the oxidizing action of the atmosphere. The chief object, however, of plunging the sheets in the grease-pot filled with heated oil, is to dry the moisture from the sheets, otherwise they would not take the tin so readily.

By melting a little tin or lead in a ladle, skimming off the dross and putting a little oil or grease on the surface of the molten metal, the effect of the grease in cleaning the surface will become evident. The palm oil comes mostly from the West Coast of Africa in large casks, holding about a half a ton. It varies in quality somewhat, a preference is given to what is known as "selected Lagos oil," which probably contains less dirt and water than the commoner sorts. Tallow would be equally well adapted for all practical purposes were it not for the very disagreeable smell resulting from its use.

It is interesting to notice something of the technical

development of the process of tinning since the year 1720, and for that purpose I have drawn largely from Flower's interesting little work on the *History of Tin and Tin-plates*. While Mr. Flower has been most thorough and careful in his historical treatment of the subject, it is to be regretted he so carefully avoids giving us anything of the modern technical details.

The old German method of tinning, as first used at Pontypool in 1720, was, of course, very crude and primitive in comparison to that of the present time.

The iron sheets were made by hammering from the bar or billet very much in the same way as the celebrated Russian sheet-iron is still made in the Urals.

The pickling was done in water acidified by the fermentation of barley meal or rye; in order to facilitate this fermentation it was necessary to place the tubs or vats in heated vaults, kept at a temperature of about 100° F. Such an acid solution being necessarily very weak, the process of pickling usually required from two to three days, and sometimes much longer. Vinegar was sometimes used for the purpose, but although stronger, it was doubtless too expensive a substitute for rye water.

Before pickling came into use, about 1747, the sheets were prepared by scouring with sand and water, and filing off the rough places, then covering them with resin before dipping into the molten tin.

Tallow or grease was used to cover the tin bath, but this produced at times such an unbearable stench that it ultimately led to the universal use of palm oil for the purpose. A little water was always added with the tallow to cause it to swell and foam. The grease or tallow always became better after being used a short time, as it seems to be a curious fact that any kind of empyreumatic fat is better for this purpose than fresh tallow or grease.

Before the rolls, for rolling the sheet out of the bath where it has its last dip (patent-pot), came into use, it was necessary to melt off the ridge or wire (list) of tin which collected on the lower edge of the sheet. For this purpose a shallow trough or pot of iron containing a bath of molten

tin about a half an inch deep was used. As soon as the ridge was melted off, the sheet was given a smart blow with a stick, which disengaged the superfluous metal, leaving only a faint streak where it was attached.

The most important improvements in the process seem to have followed each other at very long intervals, the first being in 1728, when the process of making the sheets by hammering was replaced by that of rolling. In 1745, the grease-pot for preparing the sheets for coating was first used and, in 1760, barley or rye-meal water was replaced by hydrochloric acid for the purpose of pickling. In 1783, grooved rolls for bar rolling were first used. The annealing-pot was invented by Thomas Morgan, in 1829. About 1865, the use of steel or iron rolls for rolling the sheet out of the last pot (patent-pot), became general, but from that date up to the present time, there seem to have been few or no innovations, although of course many improvements have been made in the original inventions.

About the year 1800, the idea of dividing the wash-pot into two parts seems to have been first suggested. The idea of it was simply to keep the scum (consisting chiefly of a mixture of dirt, tin oxide and grease) of the first compartment from getting into the better grade of tin used to finish the sheets in the second compartment. The necessity of skimming off the scum every time a fresh batch of sheets is put into the wash-pot is thus obviated.

The second compartment always contains the purest tin, and, as it becomes contaminated by the iron, is removed to the first compartment and finally to the tin-pot.

Before the patent-pot with its rolls came into general use, the sheets were finished by placing them in a grease-pot or bath of palm oil to "sweat off" the superfluous tin. They were first placed by the workman on a grate or basket between "pins," so-called, and removed by the grease-boy in rotation; as one sheet came out of the basket another went in, and the number of pins employed therefore regulated the time for remaining in the pot. The fewer the pins the shorter the time, and the heavier the coating, hence the longer they remained the barer the sheet.

It was usual to employ a grate of only five or six pins for charcoal sheets, while as many as up to thirty-five were employed for cheaper sheets.* The quantity of tin thus removed is about two or three times that left on the sheets.

By this arrangement the length of time the sheets remain in the pot can be regulated with considerable exactness; thus, when the temperature remains constant, the amount of tin removed or left on the sheets is regulated to a nicety.

In old times it was supposed that the addition of a very small amount of copper to the molten tin made it adhere better to the sheets. It was claimed that such an alloy possessed this quality, "because it is a medium fusibility between iron and tin." The use of the copper was known as the "secret" and "you must take care not to have either too much or too little of this secret."† The quantity of copper used seemed to depend equally upon the quality of the tin and of the iron. If too much copper is used the sheets do not look well; if, on the other hand, not enough, the sheets take too much tin. As a rule, two pounds of copper are used to 100 or 150 pounds of tin.

The idea seems to be prevalent in the United States that in order to establish a tin-plate industry in any country, it is requisite for such country to be a metallic tin producer. That such a thing is utterly wrong is, I think, fully demonstrated by the following figures:

It is stated in the official *Mineral Statistics of the United Kingdom of Great Britain and Ireland*, for the year 1889:

"The quantity of tin ore mined in Great Britain, in 1889, amounted to 13,809 tons, from which 8,912 tons of tin were obtained, against 14,370 tons of ore mined in 1888, yielding 9,241 tons of tin. The importations of tin ore and tin in 1889 amounted to 2,008 tons of ore and 30,093 tons of tin, against 2,406 tons of ore and 28,049 tons of tin in 1888."

It will thus be observed that the amount of metallic tin produced in Great Britain, in 1889, was less than one-third the amount imported. In other words, the great bulk of the

* *History of Tin and Tin-plates*, p. 171, Flower, London, 1880.

† Flower, *History of Tin and Tin-plates*, p. 171.

tin used in this country, in the forms of tin-plate, is first imported into England from foreign countries, there made into tin-plate, and then exported to the United States for consumption.

We have of late years heard much of the large deposits of tin ore discovered in various parts of this country, but the writer has yet to see the first tangible evidences of their existence. It is true, tin ore in small and scattered quantities has been discovered in the Black Hills, S. D.; at Kings Mountain, N. C.; in Virginia, Georgia, Winslow, Me.; near the town of Jackson, N. H.; Booneville, Idaho, and at San Jacinto, San Bernardino County, Cal. With the exception of those in the Black Hills it cannot be said that any of these deposits have been explored or developed to any extent. According to recent reports, the deposits of San Jacinto, Cal., appear to be very promising.* There appears to be a great similarity between the rocks and geological features of this district and those of the tin-producing districts of Cornwall.

The tin ore deposits in the Black Hills have possibly been fairly well explored, but up to the present time this district appears to have been more productive of humbugs than tin ore.

Deposits of tin ore (stream tin) have been found in some parts of Mexico, but as they have not been explored to any extent we know little of them.

* *Engineering and Mining Journal*, Oct. 18, 1890, p. 450.

A REVOLUTION IN DYEING.

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[*A Lecture delivered before the Franklin Institute, January 13, 1890.*]

[*Concluded from vol. c, p. 391.*]

GREEN DYESTUFFS.

The discovery of green dyestuffs soon followed that of the violet. One of these, methyl green, being made by the action of methyl chloride on the base of methyl violet (pentamethyl-pararosaniline), and bearing a very close relationship to that dyestuff in its constitution. Another green called iodide green was made by treating Hoffman's violet with methyl iodide, while a third known as aldehyde green was prepared from aldehyde and magenta. All of these bear a close relationship to rosaniline and were the greens used up to the year 1877, when the method of making benzaldehyde green was discovered and, owing to its superiority, it has almost entirely displaced the other greens. This last is made in quite a number of ways and is usually sold as a salt of zinc chloride, forming fine green crystals easily soluble in water. It is used only for dyeing cotton and produces a very fine green shade as seen in the sample shown.

All these dyestuffs bear a striking relationship, and in most cases their behavior towards textile fibres is the same. With the exception of the blue, they all dye wool in a neutral bath, but are little used at present for this purpose. They are mostly used for cotton, which must first be mordanted before it will take the color. Cotton blue, however, will dye unmordanted cotton in a bath to which a little alum has been added and is mostly used in this way. Alkali blue is a peculiar dyestuff and is used entirely for wool in the following manner: The dye-bath is made up with the necessary amount of dyestuff and a small amount of an alkaline salt added. The wool is boiled in this and becomes colored a very slight blue. On washing the wool and immersing it in an acid bath the coloring matter is developed into a very fine blue.

Unfortunately none of this class of rosaniline dyestuffs produce fast colors and for this reason the artificial dyestuffs have obtained a bad name, which has clung to them in spite of the fact that later discoveries have changed this entirely, as we shall see later on. If we compare the formulæ of these dyestuffs we shall see how very similar they are in their constitution and how great a change is sometimes wrought by a very slight change in the constitution. Starting with rosaniline and a very similar compound pararosaniline we have:

Rosaniline.

$$C\begin{cases} C_6H_3(CH_3)NH_2 \\ C_6H_4NH_2 \\ C_6H_4NH_2 \\ OH \end{cases}$$

Pararosaniline.

$$C\begin{cases} C_6H_4NH_2 \\ C_6H_4NH_2 \\ C_6H_4NH_2 \\ OH \end{cases}$$

Magenta.

$$C\begin{cases} C_6H_3(CH_3)NH_2 \\ C_6H_4NH_2 \\ C_6H_4NH_2 \\ Cl \end{cases}$$

Diphenylamine Blue.

$$C\begin{cases} C_6H_4NH(C_6H_5) \\ C_6H_4NH(C_6H_5) \\ C_6H_4NH(C_6H_5) \\ Cl \end{cases}$$

Acid Magenta.

$$C\begin{cases} C_6H_2(CH_3)\begin{cases} NaSO_3 \\ NH_2 \end{cases} \\ C_6H_3\begin{cases} NaSO_3 \\ NH_2 \end{cases} \\ C_6H_3\begin{cases} NaSO_3 \\ NH_2 \end{cases} \\ OH \end{cases}$$

Spirit Blue.

$$C\begin{cases} C_6H_3CH_3NH(C_6H_5) \\ C_6H_4NH(C_6H_5) \\ C_6H_4NH(C_6H_5) \\ Cl \end{cases}$$

Alkali Blue.

$$C\begin{cases} C_6H_3CH_3NH(C_6H_5) \\ C_6H_4NH(C_6H_5) \\ C_6H_4N\begin{cases} C_6H_4 \\ H \\ OSO_2 \end{cases} \\ _____/ \end{cases}$$

Alkali Blue D.

$$C\begin{cases} C_6H_4NH(C_6H_5) \\ C_6H_4NH(C_6H_5) \\ C_6H_4N\begin{cases} C_6H_4 \\ H \\ OSO_2 \end{cases} \\ _____/ \end{cases}$$

Methyl Violet 2B.

$$C\begin{cases} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ C_6H_4NHCH_3Cl \end{cases}$$

Benzyl Violet.

$$C\begin{cases} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ C_6H_4N(C_7H_7)CH_3Cl \end{cases}$$

Acid Violet.

$$C\begin{cases} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ C_6H_4N(C_7H_6NaSO_3)CH_3 \\ OH \end{cases}$$

Malachite Green.

$$C\begin{cases} C_6H_5 \\ C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2Cl \\ \text{---}/ \end{cases}$$

These few formulæ will give a good idea of the possibilities of organic chemistry in this direction.

Although these dyestuffs are not used for wool, yet in each case a corresponding sulpho compound can be made which will dye wool in an acid bath. In this way we now have acid magenta, acid violets, and acid greens all used for wool and not applicable to cotton as is seen on the sample sheet shown.

Very closely allied to this class of dyestuffs is another consisting of three members and containing a naphthyl group. These are the victoria blues, B, 4R, and night blue. The first is the hydrochloride of tetra-methyl phenyl triamido alpha-naphthyl diphenyl carbinol and from its very long name chemically it is easily seen why it is given a different name in commerce.

The compound containing a para tolyl group instead of phenyl is night blue while the penta-methyl phenyl tri-amido compound is the 4R shade.

Victoria Blue B.

$$C\begin{cases} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ C_{10}H_6NHC_6H_5Cl \end{cases}$$

Night Blue.

$$C\begin{cases} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ C_{10}H_6NH(C_7H_7)Cl \end{cases}$$

Victoria Blue 4R.

$$C\begin{cases} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ C_{10}H_6NCH_3C_6H_5Cl \end{cases}$$

These dyestuffs are used for wool, and produce very fine shades, which are quite fast to soap, but have the serious fault of rubbing off or crocking.

AURAMINE.

In the dyestuffs so far mentioned, we notice that there is not one that produces a yellow color, and the demand for a yellow that will dye mordanted cotton in connection with these basic dyestuffs for a long time remained unfilled. In 1875 a dyestuff giving a yellowish red color was discovered, but it was not until nearly ten years later that a satisfactory bright yellow was obtained. At that time a new dyestuff, called auramine, was discovered, and on mordanted cotton produces shades of very bright yellow, which are quite fast to both light and soap. Although it does not belong to the basic aniline group of dyestuffs, yet as it is used almost entirely with them, it is mentioned here. It is made by treating dimethyl aniline with carbon oxychloride in the presence of aluminium chloride. When this product is treated with ammonium and zinc chloride, the base of auramine, imido tetra-methyl di-amido di-phenyl methane, is obtained, and its hydrochloride is auramine.

$$C\begin{cases} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ NH \end{cases}$$

SAFRANINE.

This is a red coloring dyestuff, and produces very bright shades on mordanted cotton, and is also sometimes used for light pinks on wool. The dyestuff can be made in quite a

number of different ways, and is used to a considerable extent in connection with those already mentioned.

NITRO COMPOUNDS.

There are several important dyestuffs belonging to this class, the principal ones being picric acid and naphthol yellow.

PICRIC ACID.

This is made by the action of nitric acid on phenol-sulphonic acid, and is a tri-nitro phenol. It forms yellow crystals, which dye wool or silk in an acid bath a very fine greenish yellow. It was formerly much used, but has now been largely replaced by naphthol yellow S.

NAPHTHOL YELLOW.

This corresponds very closely to the above, and is the nitro compound of alpha-naphthol. It dyes wool a fine yellow, which, however, volatilizes at a moderate heat, and is not at all fast, and has now been superseded entirely by the sulpho compound.

NAPHTHOL YELLOW S.

This is often sold as naphthol yellow, acid yellow, etc. It a salt of dinitronaphthol-sulphonic acid, and dyes wool in an acid bath a pure yellow, which is only moderately fast to light and soap.

THE PHTALEIN DYESTUFFS.

By the action of phtalic acid or anhydride on phenols, bodies called phtaleïns are formed, and one of these, the anhydride of resorcinol phtaleïn, is known as fluoresceïn, and is made by heating three parts of phtalic anhydride with four of resorcinol.

Fluorescein.

$$C_6H_4\begin{Bmatrix} COC_6H_3OH \\ COC_6H_3OH \end{Bmatrix} O$$

By substituting various radicals in this compound the so-called eosine dyestuffs are produced.

The sodium salt of the tetra-brom compound is known as eosine B, and gives yellow shades of pink on wool, while the sodium salt of tetra-iodo fluoresceïn is erythrosine B, and affords bluer shades.

Eosine B.

$$C_6H_4\begin{cases}COC_6HBr_2ONa\\COC_6HBr_2ONa\end{cases}O$$

Erythrosine B.

$$C_6H_4\begin{cases}COC_6HI_2OK\\COC_6HI_2OK\end{cases}O$$

In both these compounds the substitution has been in the resorcinol group, but compounds also exist in which the substitution is in the C_6H_4 group of the phtalic acid residue.

PHLOXINE.

To this class phloxine belongs and it is the potassium salt of tetra-bromo-dichloro-fluoresceïn.

$$C_6H_2Cl_2\begin{cases}COC_6HBr_2OK\\COC_6HBr_2OK\end{cases}O$$

ROSE BENGAL.

This also belongs to this class and is the tetra-iodo-dichloro-fluoresceïn.

$$C_6H_2Cl_2\begin{cases}COC_6HI_2OK\\COC_6HI_2OK\end{cases}O$$

RHODAMINE.

This is a comparatively recent dyestuff and is obtained in an entirely different way from those already mentioned. It belongs to the amido class of dyestuffs, and is prepared by heating one molecule of phtalic anhydride with two of diethyl-meta-amido-phenol, and it has the constitution expressed by the following formula.

$$C_6H_4\begin{cases}COC_6H_3\begin{cases}N^m(C_2H_5)_2\\O\end{cases}\\COC_6H_3\begin{cases}O\\N(C_2H_5)_2\end{cases}\end{cases}$$

All of these dyestuffs are used to produce pink shades

on wool, and are dyed in a weak acid bath as a rule. With the exception of rhodamine, the shades produced are extremely fugitive and a few hours' exposure is sufficient to cause a change.

Rhodamine produces shades which are quite fast to light, and also to soap, and is in every way a dyestuff far superior to the others.

THE AZO DYESTUFFS.

A very large class of dyestuffs, comprising a number of divisions is what are known as the azo dyestuffs. These comprise by far the largest number of artificial dyestuffs and the number is greatly increased every year. It is in this field that the greatest amount of work is being done at the present time, and many of our most important dyestuffs belong to this class. Although these differ very much and are divided into a number of subdivisions, yet they are all similar in one respect, and that is in containing the group $-N=N-$

Azo benzene is the type of one of these compounds in which both the affinities of the nitrogen group have been satisfied with a phenyl group and we have for this compound the symbol

$$C_6H_5—N=N—C_6H_5$$

If the second affinity is satisfied by an acid or basic radical compounds are formed called diazo compounds and from these a large number of dyestuffs have been made.

AMIDO AZO DYESTUFFS.

These were the first of these dyestuffs made and one of their number, aniline yellow, was discovered as early as 1859 and by 1863 was a commercial product. It is not now used, but two members of the class are used quite extensively at the present time in cotton dyeing.

BISMARCK BROWN.

This is the hydrochloride of triamido-azo benzene,

$$C_6H_4(NH_2)NNC_6H_3(NH_2)_2HCl.$$

It was discovered in 1867 and is a dark brown powder,

which dyes a reddish brown shade. It is extensively used in dyeing leather and also cotton in connection with the natural dyestuffs

CHRYSOIDINE.

This was not discovered until 1875 and is the hydrochloride of diamido azo benzene,

$$C_6H_5NNC_6H_3(NH_2)_2HCl.$$

It dyes very similarly to the previous dyestuff and produces shades which are much yellower than those produced by the brown. The fastness of their shades seems to depend on the number of amido groups present, Bismarck brown being faster than chrysoidine and this in turn faster than aniline yellow which contains but one amido group.

These dyestuffs will color wool in a neutral bath but at the present time are never used for this purpose. But there are corresponding sulphonated compounds which will dye wool in an acid bath and these are used to some extent.

The principal representatives of this class are fast yellow G, derived from aniline yellow, dimethyl aniline orange, also known by various other names as orange No. 3, tropæolin D, metanil yellow, etc.

OXYAZO DYESTUFFS.

Nearly all the so-called acid colors on wool are obtained by the use of dyestuffs belonging to this class, and various shades of yellow, orange, scarlet, red, brown and finally black are possible by the use of these dyestuffs alone. Violet, blue and green dyestuff do not occur, however, and render the series incomplete, and for these we are obliged to use other dyestuffs, as acid violet, victoria blue, indigo extract, acid green, none of which yield as fast shades as the oxyazo dyestuffs. These have only been in use a comparatively short time, and since the publication, in 1878, of a scientific investigation of these compounds by Greiss, their manufacture has developed wonderfully, so that at the present time, the manufacture of the various azo dyes is the most important of all.

The great number of these dyestuffs is due to the fact that every primary aromatic amine, when converted into a diazo compound, will combine with almost any phenol or derivative of a phenol to form an azo dye. As most of these are insoluble in water, the sulphonated body is formed and the dye brought into use as a sodium sulphonated compound.

The principal amines used in the manufacture of these dyes are aniline ($C_6H_5NH_2$), toluidine ($C_6H_4CH_3NH_2$), xylidine ($C_6H_3NH_2(CH_3)_2$), alpha and beta-naphthylamine ($C_{10}H_7NH_2$) and also sulphanilic and naphthionic acids ($C_6H_4(HSO_3)NH_2$) and ($C_{10}H_6(HSO_3)NH_2$).

These can be combined with phenolic compounds as phenol (C_6H_5OH), resorcin ($C_6H_4(OH)_2$), alpha and beta-naphthol ($C_{10}H_7OH$), mono and di-sulphonic acid derivatives of the two last ($C_{10}H_5OH\ (HSO_3)_2$), etc.

While these give rise to a large number of dyestuffs, yet the number is still more increased by a property some of these possess of being diazotized and combined with other phenols giving rise to secondary azo compounds, called tetrazo dyes. These contain the group — N = N — twice, and these dyes as a rule afford faster shades than the ordinary azo dyes. Another class of the tetrazo dyes are the di-azo compounds, in which phenols, like resorcin ($C_6H_4(OH)_2$), combine with more than one molecule of a di-azo compound.

OXYAZO DYES.

As an example of this class we will take fast red. This is made by diazotizing ethyl xylidine naphthionic acid and combining it with beta-naphthol.

$$(NaSO_3)C_{10}H_6—N=N—C_{10}H_6OH.$$

Fast Red.

Among the best known of this class of dyestuffs we have the following: Archil substitute, a derivative from naphthionic acid; various scarlets, as scarlet R and 2R, cochineal scarlet 2R; fast red, bordeaux, amaranth, etc.

TETRAZO DYESTUFFS.

Scarlet.

Among the best known of the secondary azo compounds of this class are the Biebrich and croceïn scarlets, which have met with extensive use for both wool and cotton.

Brown.

Of the fast browns there are several representatives in the different acid browns.

One representative of these is the fast brown of Bayer, which has the following constitution:

$$C_6H_2(OH)_2 \begin{cases} NNC_{10}H_6(SO_3Na)\beta \\ NNC_{10}H_6(SO_3Na)\beta \end{cases}$$

Black.

Among recent discoveries in this class of tetrazo dyestuffs, that of several black dyes is to be noticed. One of these is naphthol black, and results from the action of salt R on diazotized amido azo naphthalene-disulphonic acid, and has the following constitution:

$$C_{10}H_5(SONa)_2NNC_{10}H_6NNC_{10}H_4(OH)\beta(SO_3Na)_2.$$

Another wool black is produced by the action of diazotized amido-azobenzene-disulphonic acid on paratolyl-beta-naphthylamine, and has the formula:

$$C_6H_4(SO_3Na)NNC_6H_3(SO_3Na)NNC_{10}H_6NH(C_7H_7).$$

These produce a fine black on wool from an acid bath, and are therefore much more simple to apply than a logwood black, which requires two baths. In time these will probably prove serious competitors to logwood black.

THE BENZIDINE DYESTUFFS.

These are tetrazo dyestuffs of a peculiar nature, and have been in use but a very short time, as the first one was only discovered in 1883, and it was not until several years afterward that this class became of industrial importance. They possess the peculiar property of dyeing unmordanted cotton and will also dye wool, although their use is largely confined

to cotton dyeing. Previous to their discovery, there were a few of the artificial dyestuffs used for coloring unmordanted cotton, and, as alum was usually added to the bath, these were commonly spoken of as the alum colors, this term color unfortunately being applied indiscriminately to the dyestuff as well as to the color produced by it. Cotton blue, chrysoidine, Bismarck brown and croceine scarlet and orange being the principal dyestuffs so used, but in each case the colors produced were not fast to washing. Indeed, it was thought impossible by many that any dyestuff would ever be discovered which would possess the advantages of dyeing cotton directly and also produce quite fast colors. This has been accomplished in these new dyestuffs, however, and we now have a large number with which nearly every shade can be produced.

CONGO RED.

This was the first discovered, and, as it was derived from benzidine, this name has been commonly applied to the whole class, although a large number are obtained from other compounds. Taking Congo red as a type, let us see how it is made. Benzidine has the formula

$$\begin{matrix} C_6H_4NH_2 \\ C_6H_4NH_2 \end{matrix}$$

and if this is diazotized a tetrazo compound is obtained whose hydrochloride has the formula

$$\begin{matrix} C_6H_4N=N-Cl \\ C_6H_4N=N-Cl \end{matrix} + 2C_{10}H_6(SO_3NO)NH_2 =$$

$$2HCl + \begin{matrix} C_6H_4N=NC_{10}H_5NH_2SO_3Na \\ C_6H_4N=NC_{10}H_5NH_2SO_3Na \end{matrix}$$

By combining this as before with aromatic phenols or amines, coloring substances are obtained, and if, in the above instance, napthylamine sulphonate of soda is used, congo red is obtained.

Benzidine can be produced from nitro benzene by treatment with caustic soda and zinc dust, boiling and treating the product with chlorhydric acid. The amido groups are

in the para position. Besides the dyes derived from benzidine there are others derived from a homologous base, tolidine, obtained from nitro toluidine. Among others, benzopurpurine and azo-blue are derived from this.

Another series, as Hessian purple, etc., come from still another base, obtained by treatment of a sulphonated para nitro-toluene, with caustic soda and zinc dust, as before, giving rise to diamido stilbine disulphonic acid, which, when diazotized in a chlorhydric acid solution, gives the dichloride of tetrazo stilbine di-sulphonic acid.

$$\left\{\begin{matrix}CHC_6H_3(SO_3H)\,NH_2\\CHC_6H_3(SO_3H)\,NH_2\end{matrix}\right. + 2HNO_2 = \left\{\begin{matrix}CHC_6H_3SO_3HNNCl\\CHC_6H_3SO_3HNNCl\end{matrix}\right.$$

The action takes place in two stages, so that one phenol can be used for the first part another or an amine for the second, and in this way we are able to get a very large number of dyes from each of the bases mentioned.

Congo corinth is an example of a dye of this type, and is made by the action of one molecule of tetrazo di-phenyl di-chloride with one molecule of sodium alpha-naphthylamine sulphonate, and treating the intermediate product with sodium alpha-naphthol-sulphonate.

$$\left\{\begin{matrix}C_6H_4NNC_{10}H_5(SO_3Na)^aNH_2^a\\C_6H_4NNCl\end{matrix}\right. + C_{10}H_6(SO_3Na)^aOH^a =$$

$$HCl + \left\{\begin{matrix}C_6H_4NNC_{10}H_5(SO_3Na)^aNH_2^a\\C_6H_4NNC_{10}H_5(SO_3Na)^aOH^a\end{matrix}\right.$$

From what has been stated, it is readily seen that, taking any particular base as benzidine, there are two dyestuffs possible for every two phenols used, and the same for every two amines, and by combinations of the four there are at least eight possible compounds, so that the number of these dyestuffs is being added to constantly.

Among the principal ones derived from benzidine we have chrysamine, congo red, delta purpurine G, congo corinth, benzo-azurine, R, G and 3G. From toluidine we have chrysamine R, benzo purpurine B, 4B, 6B, delta purpurine 5B, diamine red 3B, rose azurine G and B, congo corinth B, brilliant congo R.

From diamido stilbine come Hessian yellow, red, purple, violet.

These dyestuffs supply a long-felt want, and are now being extensively used for cotton and merino dyeing. For some shades they are now cheaper to use than the basic aniline dyestuffs, as the cost of labor is much less, and no doubt in time the basic dyestuffs will be largely supplanted by their improved rivals.

ANTHRACENE COLORING MATTERS.

These constitute a somewhat limited number of dyestuffs, some of which are, however, of the greatest industrial importance. They resemble each other in many of their properties, being insoluble in water and forming lakes with metallic salts. They are weak acid bodies and only dye by use of a mordant and with chromium mordants the shades are faster than any of the coal-tar colors so far mentioned, and also as fast as the fastest natural dyestuff colors. The number of these dyestuffs is also being gradually increased by new discoveries, so that at the present time we are able to produce all shades by the use of these dyestuffs alone. The first to be discovered was alizarine in 1868 by Graebe and Liebermann, but it did not come into general use for some years, due to its high cost and the difficulties attendant to the introduction of an artificial product. Commercial alizarine is a mixture of a number of very similar compounds, each of which produces its own particular shade but the difference is in degree and not in kind, so that we can consider them together. Anthracene occurs in the higher boiling products of coal-tar and is the starting point for the manufacture of alizarine. There are a number of methods of manufacture, one of which is to treat the anthracene with potassium bichromate and sulphuric acid and anthraquinone is formed, which when treated with strong sulphuric acid (fifty per cent. anhydride), gives the monosulphonic acid compound. The sodium salt of this compound, when fused with caustic soda in the presence of $KClO_3$ or KNO_3 to prevent reduction, gives sodium alizarate, which last on treatment with an acid gives free alizarine.

Anthracene. *Anthraquinone.*

$C_6H_4\overset{CH}{\underset{CH}{}}C_6H_4$ $C_6H_4\overset{CO}{\underset{CO}{}}C_6H_4$

do. Na. monosulphonate.

$C_6H_4\overset{CO}{\underset{CO}{}}C_6H_3SO_3Na$

Reaction to form sodium alizarate

$$C_6H_4\overset{CO}{\underset{CO}{}}C_6H_3SO_3Na + 3NaOH = C_6H_4\overset{CO}{\underset{CO}{}}C_6H_2(ONa)_2$$

If anthraquinone is treated with an excess of sulphuric acid, two disulphonated compounds are produced, alpha and beta, which when treated as before yield the two trioxy compounds flavo and anthra purpurine. These give yellower shades than pure alizarine and the commercial alizarine for red consists largely of these two substances.

Purpurine is another isomeric trioxy compound and is the natural coloring matter found, together with alizarine, in the madder root. When alizarine was first made it was claimed to be the same substance as that obtained from the madder root but the dyers were not able to obtain exactly the same results with it and for some time the reason for this was unknown but fuller investigation proved that the two were not identical but differed as stated above. Commercially, alizarine is sold in the form of a paste containing twenty per cent. of dry alizarine. Its present price is nineteen to twenty cents a pound and at this price it is not more than one-fourth as expensive as madder when the amount of color produced is considered. For many years, however, it sold for over a dollar a pound and at this price could not come into common use.

It is now almost universally used for all fast shades in which a red coloring matter is needed and has largely superseded the use of the natural red woods. By the use of different mordants a variety of colors can be obtained, as shown in the dyed samples. The most useful and generally used mordant for this class is bichromate of potash and the shades thus produced are exceedingly fast.

ALIZARINE ORANGE.

This is obtained directly from alizarine by treating its solution in petroleum spirit or glacial acetic acid with nitric acid, when beta-nitro alizarine, the alizarine orange of commerce, is produced. On wool, mordanted with alumina, very fine orange shades are produced, while on a chrome preparation the shade is a reddish brown. It is also used in cotton printing but its chief interest is that it is the intermediate product in the manufacture of alizarine blue.

ALIZARINE BLUE.

This is produced from alizarine orange by treatment with glycerine and sulphuric acid whereby a dihydroxy anthraquinone quinoline is produced, which is alizarine blue. It possesses both acid and basic properties and is entirely insoluble in water and as it will not remain in suspension like alizarine much inconvenience was experienced in its use. By treatment with bisulphite of soda a soluble compound is formed which is not affected by calcium or magnesium salts, or by weak acids. It is decomposed when heated above 70° C., so that when fixed on the fibre and heated above this point the insoluble compound is precipitated. This substance is now being extensively used in wool dyeing and is proving a formidable rival to vat blue. It is being extensively tried in Germany in connection with others of this class for army and police cloths.

Alizarine blue was patented in 1878 and was first introduced about 1880.

ALIZARINE BROWN.

$$C_6H_4\begin{matrix}CO\\CO\end{matrix}C_6H(OH)_3,\ \left(\begin{matrix}\alpha' & \beta' & \beta^2\\OH\ .& OH\ .& OH\end{matrix}\right)$$

This is one of the five known isomers of trihydroxy anthraquinone, four of which are coloring matters. It is not obtained from anthracene, but from the action of pyrogalic acid on phtalic anhydride, in the presence of sulphuric acid or zinc chloride.

$$C_6H_4\begin{matrix}CO\\CO\end{matrix}O + C_6H_3(OH)_3 = C_6H_4\begin{matrix}CO\\CO\end{matrix}C_6H(OH)_3 + H_2O$$

Also by the action of gallic acid on benzoic acid in the presence of sulphuric acid.

$$C_6H_5COOH + C_6H_2(OH)_3COOH =$$

$$C_6H_4\begin{matrix}CO\\CO\end{matrix} C_6H(OH)_3 + 2H_2O$$

This forms the essential constituent of commercial alizarine brown. It has been in use only a few years (having been introduced in 1886 by the Badische Company), and is dyed on wool prepared with bichromate of potash, and gives very fine shades. Its price at present prevents its use in many cases, although it is being used to a considerable extent for certain classes of work. In time it will probably prove a serious competitor to the compound browns at present used.

ALIZARINE BLACK.

This comes in the form of a paste, whose principal constituent is the bisulphite compound of napthazarine. On chromed wool it produces all shades, from a gray to a black, according to the amount used. For light gray shades it is very useful, but at its present price it cannot compete with the other blacks.

It has been introduced only some three years (1887).

GALLOFLAVINE.

This is a yellow dyestuff which was also introduced but a few years ago (1886, Badische). It yields quite bright shades of yellow on chromed wool.

ALIZARINE GREEN.

In 1888 it was discovered that alizarine blue, treated with sulphuric acid or anhydride would yield a number of products, some of which have been introduced commercially as dyestuffs.

Alizarine green and alizarine indigo blue are both made in this way, and the first yields shades of a bluish green, while the second gives shades very similar to those produced by vat indigo. At the present time these dyestuffs are rather expensive, owing to the roundabout method by

which they are produced, but if a more direct and cheaper method of making them is discovered, they will, no doubt come into very general use.

Besides these dyestuffs, which are directly related to anthracene, we also have a few others derived from pyrogallic acid and whose constituents are still unsettled. These dye similarly to those of the anthracene group, and may in fact belong to that class of dyestuffs, but so far they have not been fully investigated, and it is not known fully just where they belong chemically.

GALLEIN.

This is made by heating pyrogallic acid and phtalic anhydride to 200° C. and dissolving the product in sodium carbonate and then on treatment with acid the coloring matter is precipitated.

$$C_6H_4\begin{matrix}CO\\CO\end{matrix}O + 2C_6H_3\begin{Bmatrix}OH\\OH\\OH\end{Bmatrix} + O =$$

$$C\begin{Bmatrix}C_6H_2\begin{Bmatrix}OH\\O\\O\end{Bmatrix}\\C_6H_2\begin{Bmatrix}O\\O\\H\end{Bmatrix}\\C_6H_4CO\\O'\end{Bmatrix} + 3H_2O$$

The dyestuff comes in the form of a paste and on chromed wool gives a very fine purple shade.

The dyestuff is also sometimes called anthracene violet, alizarine violet, etc.

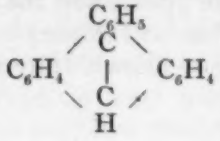
COERULEIN.

This is made from the above by treatment with strong sulphuric acid and the dyestuff thus produced is a black precipitate nearly insoluble in water. By treatment with reducing agents in an alkaline solution coeruleïn, the phtaleïn of coeruleïn, is formed and this can be used in dyeing similarly to the indigo vat. By treatment with a bisulphite, coeruleïn is converted into a soluble compound which will

dye chromed wool a very fast green and which can also be used in cotton printing.

The constitution of coeruleïn is not fully known but it is supposed to be a derivative of phenyl anthracene and if so belongs to the anthracene dyestuffs.

Phenyl anthracene.



Coeruleïn.

$C_{20}H_8O_6$

THE ARTIFICIAL VS. NATURAL DYESTUFFS.

The earlier artificial coal-tar dyestuffs produced shades so much more beautiful than those produced with the natural dyestuffs that, at first, the accompanying lack of permanency was not so much considered. As time went on, however, there was a reaction, and a demand for fast and bright colors arose, and at the present time the tendency is to discard very fugitive coloring matters and replace them by those that are fast or fairly so. The acid azo compounds were a great advance over those previously used, and many of them are as fast or faster than many of the natural coloring bodies. It was not, however, until the discovery of the anthracene series that fast shades of every color were made possible, and not only are these as fast as the natural dyestuffs, but they are far superior in point of brightness. One great advantage in the use of the artificial dyestuffs is that in each group of those dyed in the same way we have those which will produce the three primary colors, so that, by proper combination, all shades can be produced in one dyeing operation. As the natural dyestuffs do not possess this advantage, and many of the shades produced by them require two or more dyeing operations, the result has been that they have been largely displaced by the artificial products and only those which present some special advantages meet with any extensive use. Principally among these are logwood, fustic, indigo and cutch, all of which are used in enormous quantities; but even now the first and last have

strong competitors in the artificial dyestuffs, and it is not impossible that in time all the natural coloring matters may be entirely superseded.

MANUFACTURE OF THE ARTIFICIAL DYESTUFFS.

Since the discovery of the first artificial coal-tar dyestuffs, the manufacture of these products has grown constantly, until now it is an industry of great magnitude and importance. In this country, there are several places where this manufacture is carried on, but as a rule the number of dyestuffs made in any one place is somewhat restricted, and in some cases the entire product is confined to a very small number, as magenta, cotton blue, etc. In England, France, Germany, and some other countries, but especially in Germany, this industry has attained its greatest growth, and in some cases the works are so large as to resemble a small town or village. To show this more clearly, the following statistics are given of the size of one of these works, that of the Farbwerke, at Hoechst-on-Main, as given in their report of the celebration of their twenty-fifth anniversary in 1888.

They employ 1,860 workmen, fifty foremen, nine engineers, besides eighty-six clerks and fifty-seven chemists. The works cover an area of 726,000 square yards, and from one end of the works to the other the distance is 3,300 feet. Besides a great variety of dyestuffs, the acids used in their production are also manufactured, and the production for one year was as follows:

Kilograms of sulphuric acid,	23,108,000
Kilograms of other acids,	12,800,000
Kilograms of coal-tar products,	3,624,000

Statistics of other works are not at hand, but the above will give a good idea of the enormous size to which some of them have grown. Another important company—the Badische—has works at Ludswigshafen, Stuttgart, Neuville and Moscow.

All the foreign dyestuff manufacturers are represented by agents here, and enormous quantities of dyestuffs are imported yearly. With the exception of alizarine, these

have to pay quite a heavy duty, so that possibly some time we may be able to manufacture more of these products here and more nearly supply our wants than is the case at present.

In concluding this lecture, I desire to express my thanks to the different dyestuff firms of this city for their kindness in supplying their latest productions, and in this way making it possible to bring to your attention some products which have not yet come into general use.

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A NEW THEORY OF THE PROPAGATION OF WAVES IN LIQUIDS.

BY L. D'AURIA.

While a wave is propagated in a liquid, the particles of the liquid which at a given instant are on any given vertical plane $X\,X$ (*Figs.* 1 and 2), perpendicular to the direction of

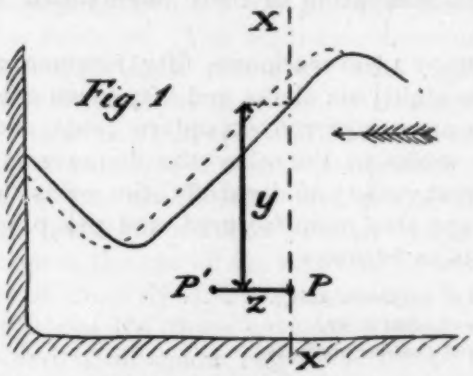


Fig. 1

the propagation, will, at the next instant, be found displaced to one side, or to the other, of such plane; and the volume of liquid thus displaced, which we indicate by δQ, will be either added to, or subtracted from, the volume Q of the wave, which at the given instant is confined between the plane $X\,X$, and the abutment to the wave propagation.

Let v, represent the velocity of propagation; γ, the weight of one cubic foot of liquid; and g, the acceleration

of gravity. The amount of energy which the variation of volume δQ implies is

$$E = \frac{v^2}{2g} \gamma \delta Q$$

On the other hand, if we denote by z, the horizontal displacement $P P'$ of a liquid particle P, at the depth y, below the surface of the wave, right on the plane $X X$, the work which the displacement z, implies is $\gamma z y dy$; and the work implied in the displacement δQ will be

$$W = \gamma \int_0^h z y dy$$

in which h represents the whole depth of the liquid to

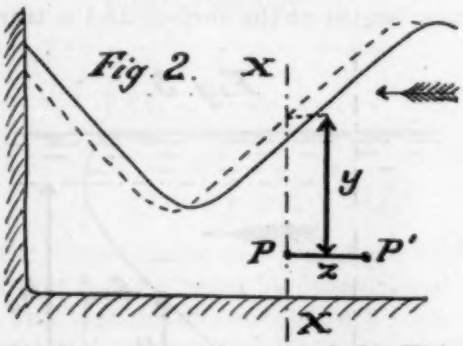


Fig. 2.

which the displacement z is extended. This work must equal the energy E, at every instant, hence it follows

$$v^2 = \frac{2g}{\delta Q} \int_0^h z y dy \qquad (1)$$

Now, in regard to z, we can put $z = f(y)$; and observing that

$$\delta Q = \int_0^h f(y) dy$$

we can write

$$v^2 = 2g \frac{\int_0^h f(y) y dy}{\int_0^h f(y) dy} \qquad (2)$$

But the quantity

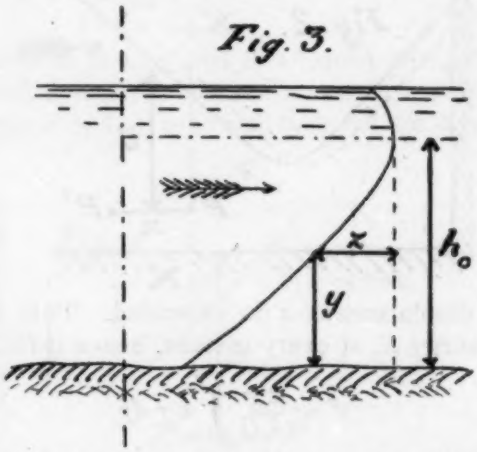
$$\frac{\int_0^h f(y)\, y\, dy}{\int_0^h f(y)\, dy}$$

represents nothing else but the distance Y, of the centre of gravity of the displacement ∂Q from the surface of the wave; consequently, the velocity of propagation of waves in liquids is expressed by the general formula

$$v = \sqrt{2gY} \qquad (3)$$

In the case of sea waves raised by the action of the wind, the disturbance begins at the surface and is transmitted to

Fig. 3.



the lower particles of the liquid mass by cohesion. The law of this transmission can be fortunately deduced from the effect the resistance of river beds produce upon the velocity of streams. In fact, we know that, were it not for such resistance, the velocity of streams would be equal in all parts of the cross-section; and that the effect of such resistance is to make the velocity vary from the bottom to the surface according to a law well represented by a parabola whose axis is horizontal and somewhat below the surface, as shown in *Fig. 3*. Thus we know that the dis-

turbance of the particles at the bottom of the stream is transmitted to the other particles according to the law

$$z = \frac{(h_0 - y)^2}{p}$$

in which h_0 is the depth below the vertex of the parabola, and p the parameter of such parabola. This same law holds good also when the disturbance begins at the surface, since the cohesion of the liquid particles is independent of pressure; hence denoting, in this case, by h_0 the depth of the liquid where the horizontal displacement z ceases, we have

$$y = \frac{\int_0^{h_0} (h_0 - y)^2 \, y \, dy}{\int_0^{h_0} (h_0 - y)^2 \, dy} = \tfrac{1}{4} h_0$$

or

$$y = \tfrac{1}{4} \sqrt{p z_0}$$

where z_0 is the displacement of a liquid particle at the surface. Observing that $p z_0$ must be proportional to the force of the wind, and that the measure of such force can be seen in the amount of liquid raised above the surface, we can assume $p z_0$ proportional to λR, in which λ is the length, and R the height of the wave. Then we can write

$$v = c \sqrt[4]{\lambda R} \qquad (4)$$

in which the coëfficient c is to be determined by observation.

According to the observations taken by Dr. Scoresby, in 1848, on the Atlantic Ocean, waves averaging 26 feet in height and 560 feet in length, have a velocity of propagation of about 48 feet per second. With these data, equation (4) gives $c = 4{\cdot}37$, approximately.

Again, according to other observations taken by independent observers, it is found that waves averaging 15 feet in height and 300 feet in length, have a velocity of propaga-

tion of about 36 feet per second. With these data, equation (4) gives $c = 4{\cdot}39$, approximately.

The closeness of these two values of c is certainly remarkable, considering the diversity of the data presented in the two sets of observations reported above. We can, therefore, write with confidence

$$v = 4{\cdot}38 \sqrt[4]{\lambda K} \tag{5}$$

In the case of the tide wave raised by the action of the luni-solar disturbing force upon the waters of the oceans, we know that the horizontal component of such force at any given place is constant at all depths, and therefore the displacement z is also constant. Consequently, we have $Y = \frac{1}{2} h$, in which h is the whole depth of the ocean; and substituting in equation (3), we find

$$v = \sqrt{g h} \tag{6}$$

In tidal rivers, if we denote by u_0, u_1 and u_2, respectively the mean, the surface and the bottom velocities at any given instant in any cross-section whose depth at that instant is h, we find, assuming the parabolic law of velocities in the same vertical,

$$Y = \tfrac{1}{4} h \frac{u_1 + u_2}{u_0}$$

and consequently

$$v = \sqrt{g h \frac{u_1 + u_2}{2 u_0}} \tag{7}$$

We may for simplicity put

$$\frac{u_1 + u_2}{2 u_0} = \mu \tag{8}$$

and write

$$v = \sqrt{\mu g h} \tag{9}$$

There is another reduction to be applied to this formula when the depth h is variable in the same cross-section. Suppose the depth at a distance x, from one end of the cross-section, be represented by

$$y = f(x)$$

then, in order to compute the mean velocity of propagation

of the wave through such cross-section, we have to use the formula

$$v = \frac{\sqrt{g}}{b} \int_0^b \left[f(x) \right]^{\frac{1}{2}} dx$$

in which b represents the width of the cross-section from one end to the other.

Observing that the mean depth of the cross-section is expressed by

$$H = \frac{1}{b} \int_0^b f(x)\, dx$$

we can write

$$v = \frac{\int_0^b \left[f(x) \right]^{\frac{1}{2}} dx}{\sqrt{b} \left[\int_0^b f(x)\, dx \right]^{\frac{1}{2}}} \sqrt{g H}$$

If we put

$$y = f(x) = p\, x^n$$

we find

$$\frac{\int_0^b \left[f(x) \right]^{\frac{1}{2}} dx}{\sqrt{b} \left[\int_0^b f(x)\, dx \right]^{\frac{1}{2}}} = \frac{2\sqrt{n+1}}{n+2}$$

and consequently, equation (9) becomes

$$v = \frac{2}{n+2} \sqrt{\mu (n+1)\, g H} \qquad (10)$$

Denoting by (H_1) and (H_2), the mean depths of high water and low water in a given length l of a tidal river, then the mean velocities of the crest and the trough of the tidal wave in such distance will be expressed, respectively, by

$$v_1 = \frac{2}{n+2} \sqrt{\mu g (n+1) (H_1)} \qquad (11)$$

and

$$v_2 = \frac{2}{n+2} \sqrt{\mu g (n+1) (H_2)} \qquad (12)$$

The value of μ in these expressions is not necessarily the same. Suppose, for instance, that the river basin enlarges considerably at a certain point, so as to become a kind of reservoir to the river below. If the enlargement were very great, we know that the level of water there would not be affected by tide and would stand at the same elevation as the mean level of the ocean. The effect, therefore, of any enlargement of basin in a tidal river is to more or less reduce the range of tide, and to more or less elevate the plane of low water where the enlargement occurs over the plane of low water of the river below. Hence, while the trough of the tidal wave is advancing in this portion of the river, a more or less strong current, due to the higher elevation of the plane of low water in the enlarged basin, will meet the advancing wave, and finds its escape below the surface, or rather near the bottom, where it adds strength to the bottom velocity u_2 of the ebb. Consequently the value of μ in such case, in equation (12), may be considerably larger than the value of μ in equation (11), since there is no reason for an enlargement of basin to affect the bottom velocity u_2 during high water in any cross-section of the river.

The bottom velocity u_2 during low water is certainly increased when the river discharges a considerable volume of fresh water through the cross-section, for this discharge also finds an easy escape near the bottom, on account of the advancing wave. In both cases, the tendency is, therefore, to increase the value of μ in equation (12); and if we assume that in such cases the bottom velocity does not differ much from the surface velocity, we may consider $\mu = 1$, in such equation.

In ordinary cases, the bottom velocity may be considered small compared with the surface velocity, and then we find according to equation (8), $\mu = \frac{3}{4}$.

As to the value of n, it is safe to assume that the cross-section approaches the parabolic form, when $n = \frac{1}{2}$. Then, taking $g = 32{\cdot}17$, we find in ordinary cases

$$v_1 = 4{\cdot}81 \sqrt{(H_1)} \tag{13}$$

$$v_2 = 4{\cdot}81 \sqrt{(H_2)} \tag{14}$$

and for the cases, where the volume of fresh water discharged by the river is considerable with respect to the tidal volume, or where a considerable enlargement of basin occurs, as mentioned above, we may put (assuming $\mu = 1$),

$$v = 5{\cdot}56\sqrt{(H_2)} \tag{15}$$

Denoting by θ_1 and θ_2 the delays in minutes of high water and low water in the distance l computed in statute miles, we find, in ordinary cases, the following formula:

$$\theta_1 = \frac{18{\cdot}3\ l}{\sqrt{(H_1)}} \tag{16}$$

$$\theta_2 = \frac{18{\cdot}3\ l}{\sqrt{(H_2)}} \tag{17}$$

and, when the velocity of propagation of the trough is computed according to formula (15), we find

$$\theta = \frac{15{\cdot}8\ l}{\sqrt{(H_2)}} \tag{18}$$

Whenever we find that the delay of low water in a given portion of a tidal river corresponds with this formula, we have an evidence that, during low water, the bottom velocity of the ebb is greater than it otherwise would be under ordinary conditions; and this increment of bottom velocity must be due either to a considerable volume of fresh water passing through the various cross-sections of the considered portion of river, or to a considerable enlargement of tidal basin above such portion of river. (These facts may be turned to some advantage in the improvement of tidal rivers.)

In order to test the accuracy of the formulæ (16) and (17), we have selected the portion of the Delaware River between Edgemoor and Fort Mifflin, in which the delays of high water and low water from nearly 400 observations are found to be 73 minutes and 81 minutes, respectively. The distance between the stations is $l = 18{\cdot}7$ statute miles, and from numerous soundings and careful reductions made by the U. S. Coast and Geodetic Survey (*Rep.* 1887), is found

$(H_1) = 20{\cdot}5$ feet, $(H_2) = 18{\cdot}3$ feet. With these data, our formulæ furnish

$$\theta_1 = 75{\cdot}5 \text{ minutes},$$

$$\theta_2 = 80{\cdot}0 \text{ minutes},$$

results which are certainly very satisfactory.

If we take the portion of the upper Delaware above Philadelphia, from Bridesburg up to Burlington, we have a case where the volume of fresh water discharged by the river is considerable when compared to the tidal volume, and consequently for the delay of low water we may use the formula (18). Now the distance between the stations is $l = 12{\cdot}5$ statute miles; and according to a recent determination made by the United States Engineers, the delays of high water and low water are 59 minutes and 55 minutes, respectively, and $(H_1) = 14{\cdot}2$ feet, $(H_2) = 13{\cdot}7$ feet. With these data, we find

$$\theta_1 = 60{\cdot}7 \text{ minutes},$$

$$\overset{1}{\theta}_2 = 53{\cdot}5 \text{ minutes},$$

also very satisfactory results.

Again, the portion of the Hudson River, from Governor's Island to Dobbs' Ferry is found below an enlargement of basin which is called Tappan Sea, and, therefore, the delay of low water must also be computed according to formula (18).

The distance between the stations is $l = 24$ statute miles and the Tide-Tables give for the delays of high water and low water 72 minutes and 60 minutes, respectively. According to a publication by the U. S. Coast and Geodetic Survey, we find $(H_1) = 38{\cdot}7$ feet, $(H_2) = 34{\cdot}1$ feet. With these data we get

$$\theta_1 = 70{\cdot}6 \text{ minutes},$$

$$\overset{1}{\theta}_2 = 65{\cdot}0 \text{ minutes},$$

which results, though not so satisfactory as before, are not at all improbable. In fact, so far as the delay of high

water is concerned the agreement between the observed and computed values is certainly very good; and the difference of five minutes which appears between the computed and the observed delay of low water only shows that the value of μ, in the present case, is somewhat larger than *one*.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE

[*Stated Meeting, held at the Institute, Tuesday, November 18, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 18, 1890.

Mr. T. C. Palmer, President, in the Chair.

Members present: Dr. L. B. Hall, Dr. H. W. Jayne, Mr. H. Pemberton, Jr., Mr. C. J. Semper, Dr. S. C. Hooker, Dr. Wm. H. Greene, Prof. E. F. Smith, Mr. Reuben Haines, Mr. W. W. Macfarlane, Mr. A. A. Moore, Dr. Wm. H. Wahl, Mr. Philip S. Clarkson, and a number of visitors.

The election of Mr. Cabell Whitehead, of the Mint Bureau at Washington, as an associate member of the Section, was announced.

Mr. Pemberton nominated Mr. Richard D. Baker, 216 South Third Street, Philadelphia, as a member of the Section. The nomination was referred to the Committee on Admissions.

A letter from Mr. Heyl, the Actuary of the Institute, was read, in which certain recommendations were made relative to the course to be pursued in paying bills for journals, etc., the contracting of which had already been formally sanctioned by the Section. The views expressed met with the approval of the Section and the Secretary was directed to so inform the Actuary.

On motion of Mr. Pemberton, it was voted that the Secretary of the Institute be authorized to renew the subscriptions to the journals taken by the Section.

Prof. Smith moved that the Section subscribe for the Bulletin of the French Chemical Society; the motion was carried.

At the suggestion of the treasurer it was voted that he be authorized to purchase 1,000 envelopes for the use of the Section.

On motion of Mr. Pemberton, it was voted that the Section suggest to the Library Committee of the Institute the propriety of completing the sets of all the journals taken by the Section.

The report of the Committee on the Publication of the Paper by Dr. Masser, of Los Angeles, Cal., on "The Curve of the Elements," and also another by Dr. Hans von Strombeck, of New York, on "The Constants of Ammonia," was accepted and the committee was discharged.

On motion of Dr. Wahl, it was voted that a committee be appointed to prepare a circular-letter addressed to chemists at large, setting forth the facilities possessed by the Section to receive, examine and publish promptly papers of meritorious character on chemical subjects.

In this circular-letter, he proposed also to call attention to the fact that a number of printed copies of an accepted paper would be returned to the author, within two weeks of the date of its acceptance by the Section; and furthermore to the fact that the publications of the Section are forwarded promptly, as advance sheets, to the leading chemical journals at home and abroad.

The following nominations of officers for the ensuing year were then made: For President, Dr. Wm. H. Wahl; for Vice-Presidents, Mr. H. Pemberton, Jr., and Dr. Wm. H. Greene; for Secretary and Treasurer, the present incumbents in each case; for Conservator, Dr. Wahl.

Dr. Greene then presented a paper by himself and Dr. Wahl, on "Alloys of Sodium and Lead." It was referred for publication in the Journal.

Dr. Greene also stated that he would submit a number of specimens of new alloys proposed by the authors at the next meeting.

Dr. Wahl then read an abstract prepared by Prof. C. F. Himes, of Carlisle, describing a new photographic process without the use of metallic salts, based on the light sensitive properties of primuline. It was referred for publication. In connection with this paper Mr. Macfarlane stated that the active substance of the process, known as "primuline," and the primuline dyes in general, had been abandoned in dyeing, because of the fact that they would stand exposure to direct sunlight for only a short time before fading out.

Dr. Jayne called attention to a chart illustrating clearly the details of the new process for manufacturing nitric acid, invented by Oscar Goodman, and recently described in various journals.

Mr. Palmer exhibited a piece of logwood which was unusual in presenting a bronzy green surface, such as is commonly found only in chipped wood that has been put through the process of curing. This fragment was part of a log six feet in length, taken from a wind-shaken tree through which rain-water had percolated. The rain-water, probably by the action of the ammonia contained in it, had produced a result analogous to that secured by the usual curing process.

Adjourned.

WM. C. DAY, *Secretary.*

On some CONSTANTS of AMMONIA.*

By Dr. Hans von Strombeck.*

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If we have to calculate the dimensions of a refrigerating machine it is absolutely necessary to know the exact value of the heat of evaporation (latent heat) of the liquid by means of which the cooling effect is produced. Though in these calculations all designers take the heat of evaporation of liquid ammonia to be about 540 English or 300 French thermal units, nevertheless many of them claim the heat of evaporation of ammonia to be in reality about 900 English or 500 French thermal units. The reason for this assertion is that on being determined the first time the heat of evaporation was found to be about 500 French thermal units. But, as afterwards it was proven that the ammonia used in this test contained a good deal of water, H. V. Regnault repeated the tests with ammonia, absolutely free of any moisture, and found the average figure of the heat of evaporation to be 294·2 French thermal units. To prove once more that this latter figure is correct, and also to decide some other questions relating to ammonia, at the suggestion of Mr. Louis Block, Chief Engineer of the De La Vergne Refrigerating Machine Company, I determined by a series of tests:

(1) The specific heat of liquid ammonia;

(2) The total heat, heat of evaporation and heat of liquid of ammonia;

(3) The heat of absorption of ammonia;

(4) The heat of combination of liquid ammonia and water.

To this is added:

(5) A table showing the difference in the figures for the total heat of evaporation and the heat of absorption.

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* From the laboratory of the De La Vergne Refrigerating Machine Co.

I.—DETERMINATION OF THE SPECIFIC HEAT OF LIQUID AMMONIA.

The determination was made in the usual way: The steel cylinder (μ_2) containing the liquid ammonia (M) was suspended in a jacketed drum and heated up to a certain temperature ($T + \delta_1$) by means of the vapor of boiling methylic alcohol which circulated in the jacket. After the liquid ammonia was heated up to a constant temperature, which took about six hours, the steel cylinder (μ_2) with its contents (M) was quickly put in the brass calorimeter (μ) which was filled with a certain quantity of distilled water (m) of a certain temperature (t). By the heat given to m and μ by M and μ_2, the temperature of the water rose from t degrees to $\tau + \delta$ degrees. From the figures thus obtained the specific heat of the liquid ammonia can be calculated.

In the following, all temperatures are in degrees Celsius, all weights in grammes, all measures in cubic centimetres, all thermal units are French ones. The liquid ammonia used in all the following tests was manufactured in the gas plant of the De La Vergne Refrigerating Machine Company.

Its composition was:

99·926 per cent. ammonia;
0·055 per cent. mineral oil (liquid base) which originates from a patented process used in the manufacture of the liquid ammonia;
0·019 per cent. moisture.

If, in the following:

M = the weight of the gaseous and liquid ammonia and its contaminations in the steel cylinders;
$M - \mu_3 - \mu_4 - \mu_6$ = the weight of the liquid ammonia;
m = the weight of the water in the calorimeter;
μ = the weight of the brass calorimeter and the metal part of the agitator;
σ = its specific heat;
$\mu\sigma$ = its value in water;
$\mu_1\sigma_1$ = the value in water of the thermometer in the calorimeter;

μ_2 = the weight of the steel cylinder;
σ_2 = its specific heat;
$\mu_2 \sigma_2$ = its value in water;
v = the contents of the steel cylinder in cubic centimetres;
$\epsilon (T + \delta_1)$ = the specific gravity of liquid ammonia at $T + \delta^1$ degrees;
$\phi (T + \delta_1)$ = the pressure in atmospheres exerted by gaseous ammonia at $T + \delta^1$ degrees;
μ_3 = the weight of the gaseous ammonia above the liquid at $T + \delta^1$ degrees and corresponding pressure;
σ_3 = its specific heat at constant volume;
$\mu_3 \sigma_3$ = its value in water;
μ_4 = the weight of the mineral oil contained in $M - \mu_3$ grammes of liquid ammonia;
σ_4 = its specific heat;
$\mu_4 \sigma_4$ = its value in water;
μ_6 = the weight of the moisture contained in $M - \mu_3$ grammes of liquid ammonia;
$\epsilon (\tau + \delta)$ = the specific heat of liquid ammonia at $\tau + \delta$ degrees;
$\phi (\tau + \delta)$ = the pressure in atmospheres exerted by gaseous ammonia at $\tau + \delta$ degrees;
μ_5 = the weight of the gaseous ammonia above the liquid at $\tau + \delta$ degrees and corresponding pressure;
$\mu_3 - \mu_5$ = the weight of the gaseous ammonia, which became a liquid when the temperature went down from $T + \delta_1$ to $\tau + \delta$ degrees;
r = the heat of evaporation of liquid ammonia in thermal units;
$(\mu_3 - \mu_5) r$ = thermal units developed by the liquefaction of $\mu_3 - \mu_5$ grammes of gaseous ammonia;

t = the temperature indicated by the thermometer in the water of the calorimeter at the beginning of the test;

τ = the temperature indicated by the thermometer in the water of the calorimeter at the end of the test;

δ = the fraction of a degree, which is to be added to τ, so as to obtain the temperature;

$\tau + \delta$ which the water in the calorimeter would have had, if no loss of heat had taken place by the cooling influence of air and by radiation;

$\tau + \delta - t$ = the corrected number of degrees by which the water in the calorimeter was heated up;

T = the temperature of the gaseous and liquid ammonia and its contaminations in the steel cylinder and of the cylinder itself, as indicated by the thermometer;

δ_1 = the fraction of a degree, which is to be added to T, so as to obtain the temperature;

$T + \delta_1$ which the thermometer would have indicated if its mercury column had not projected over the cover of the jacketed drum;

$T + \delta_1 - (\tau + \delta)$ = the decrease of temperature, which the gaseous and liquid ammonia and its contaminations in the steel cylinder and the cylinder itself underwent;

x = the specific heat of liquid ammonia that is to be determined.

We have—

$$x = \frac{(m + \mu\sigma + \mu_1\sigma_1)(\tau + \delta - t) - (\mu_2\sigma_2 + \mu_3\sigma_3 + \mu_4\sigma_4 + \mu_6)(T + \delta_1 - (\tau + \delta)) - (\mu_3 - \mu_5)\tau}{(M - \mu_3 - \mu_4 - \mu_6)(T + \delta_1 - (\tau + \delta))}$$

	1.	2.	3.	4.	5.	6.	7.	8.
M,	128·3	128·1	128·1	128·1	128·1	128·0	128·0	128·0
$M - \mu_2 - \mu_4 - \mu_6$,	127·7516	127·5313	127·5276	127·5146	127·5237	127·4266	127·4262	127·4206
m,	980·0							
μ,	216·2							
σ,	0·0939							
$\mu\sigma$,	20·30							
$\mu_1\sigma_1$,	6·37							
μ_2	1357·6							
σ_2,	0·117687	These values are the same in all eight tests.						
$\mu_2\sigma_2$,	159·77							
v,	262·75							
μ_4,	0·071							
σ_4,	0·4618							
$\mu_4\sigma_4$,	0·033							
μ_6,	0·024							
r,	294·2							
$\varepsilon T + \delta_1$,	0·5470	0·5466	0·5471	0·5473	0·5462	0·5469	0·5457	0·5454
$\phi T + \delta_1$,	27·06	27·21	26·98	26·92	27·41	27·13	27·55	27·69
μ_3,	0·4734	0·4737	0·4774	0·4904	0·4813	0·4784	0·4788	0·4844
σ_3,	0·3606	0·3606	0·3606	0·3606	0·3606	0·3606	0·3606	0·3606
$\mu_3\sigma_3$,	0·1707	0·1718	0·1721	0·1769	0·1735	0·1795	0·1737	0·1747
$\varepsilon\tau + \delta$,	0·5895	0·5929	0·5926	0·5907	0·5965	0·5892	0·5886	0·5893
$\phi\tau + \delta$,	12·15	11·87	11·35	11·79	11·24	12·23	12·45	12·19
μ_5,	0·3317	0·3636	0·3624	0·3704	0·3854	0·3784	0·3833	0·3788
$\mu_3 - \mu_5$,	0·1417	0·1101	0·1150	0·1200	0·0959	0·1000	0·0955	0·1056
$(\mu_3 - \mu_5)\,r$,	41·68	32·66	33·83	35·30	28·21	29·42	28·10	31·06
t,	21·50	18·25	18·64	20·40	18·00	21·83	22·20	21·39
τ,	31·15	28·71	28·93	30·28	28·67	31·42	32·00	31·38
δ,	0·139	0·092	0·09	0·114	0·054	0·119	0·073	0·095
$\tau + \delta$,	31·289	28·802	29·02	30·394	28·724	31·539	32·073	31·475
$\tau + \delta - t$,	9·789	10·552	10·38	9·994	10·724	9·709	9·873	10·085
T,	62·17	62·45	62·05	61·97	62.70	62·26	63·02	63·14
δ_1,	0·075	0·077	0·075	0·069	0·073	0·078	0·07	0·073
$T + \delta_1$,	62·245	62·527	62·125	62·039	62·773	62·338	63·09	63·213
$T + \delta_1 - (\tau + \delta)$,	30·956	33·725	33·105	31·645	34·049	30·799	30·017	31·738
x,	1·22888	1·20757	1·21242	1·22941	1·22563	1·22720	1·25191	1·24707

Average of x, ... 1·22876

As this result was somewhat surprising, I wanted to make absolutely sure that no mistake had taken place in these tests; I therefore filled distilled water into the steel cylinder μ_2 and determined its specific heat. As I expected, I got a value close to one, namely 0·99302.

The values of μ_3 and μ_5 were calculated in the following manner; I take the figures obtained in the sixth test for example:

(1) μ_3: $T + \delta_1 = 62{\cdot}338°$ $\varepsilon T + \delta_1 = 0{\cdot}5469$ $\phi T + \delta_1 = 27{\cdot}13$ atm.

$M = 128{\cdot}0$ grs. $v = 262{\cdot}75^{cm}$ 1^{cm} of gaseous ammonia weighs at 0° and 760^{mm} pressure 0·0007614 grammes. Consequently, if the steel cylinder were entirely filled with liquid ammonia, its contents would weigh $262{\cdot}75 \times 0{\cdot}5469 = 143{\cdot}68$ grs. As they weigh only 128·0 grs., we have the following equation: $262{\cdot}75^{cm} : 143{\cdot}68$ grs. $= x^{cm} : 128{\cdot}0$ grs. $x = 234{\cdot}04^{cm}$ were filled with liquid ammonia. The rest $262{\cdot}75 - 234{\cdot}04 = 28{\cdot}71^{cm}$ were filled with gaseous ammonia, which under the prevailing circumstances weigh

$$\frac{28{\cdot}71 \times 0{\cdot}0007614 \times 27{\cdot}13 \times 273}{273 + 62{\cdot}338} = 0{\cdot}4784 \text{ grs.}$$

(2) μ_5: $\tau + \delta = 31{\cdot}539°$ $\varepsilon\tau + \delta = 0{\cdot}5892$ $\phi\tau + \delta = 12{\cdot}23$ atm. Doing the same calculations as above we obtain $x = 217{\cdot}43^{cm}$, or $45{\cdot}32^{cm}$ were filled with gaseous ammonia, which weigh 0·3784 grs.

II.—DETERMINATION OF THE TOTAL HEAT—HEAT OF EVAPORATION AND HEAT OF LIQUID OF AMMONIA.

In making this test I generally followed the course taken by H. V. Regnault (cf. *Ann. d. chim.*, xxiv, p. 375, pf.), but made the following two modifications:

(1) I introduced the value 1.22876 determined sub. I) for the specific heat of ammonia which Regnault supposed to be 0·799.

(2) I determined the value y_1 (cf. p. 476, pf.) which is necessary to be known for the calculation of the total heat and heat of liquid.

The test was made in the following way: The apparatus consists of two calorimeters *ABCD* and *EFGH*, which are

filled in each test with 4,300 and 600 grs. of water respectively. Three tanks securely connected with each other by the brass-block *abcd* are put in the first calorimeter. Tank *IKL* is filled with the liquid ammonia *P*. During the test the ammonia gas escapes through the cock *Z* (the construction of which allows the regulation of the escape of the ammonia in the minutest manner) and the tanks *MNO* and *PQR* into

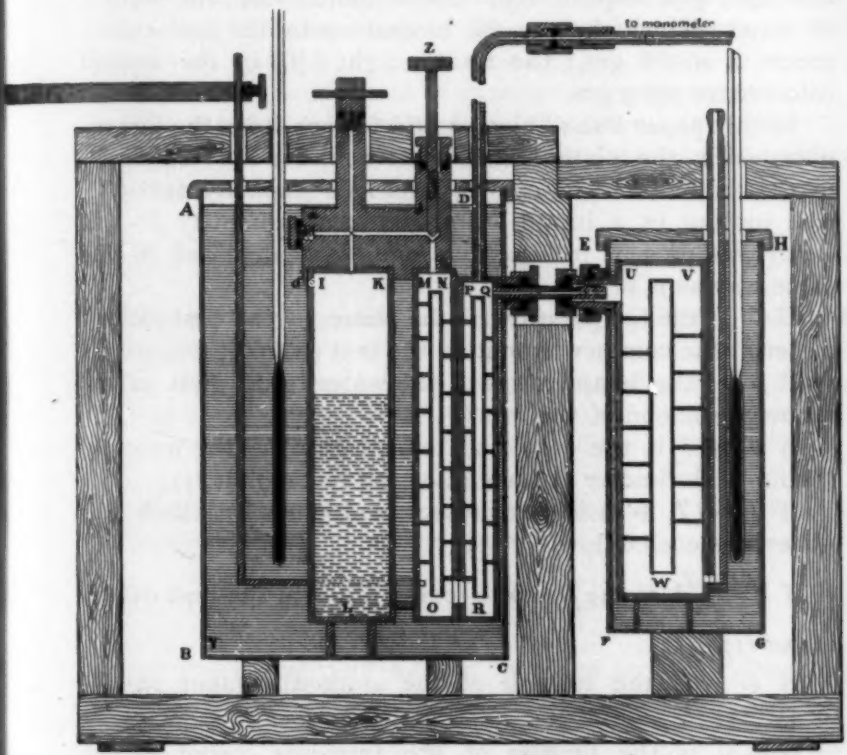


FIG. 1. Apparatus for the Determination of the Latent Heat of Ammonia.

tank *UVW*, put in the second calorimeter, and from it into the atmosphere. Small semi-circular plates are spirally fixed in these tanks so as to cause the gas to entirely equalize its temperature with that of the surrounding water. A small mercury manometer connected with *PQR* allows the control of the pressure of the escaping gas at any moment. By means of the agitator *y*, the temperature of the water is

kept the same in all strata. To lessen the influence of the air and to prevent the calorimeters as much as possible from radiating, the calorimeters are covered with wooden covers and the whole apparatus put in a wooden box.

The first calorimeter with its three tanks weighs 3,800 grs.; the second one 1,579 grs. The specific heat of their material (brass) being 0·0939 their values in water are 356·8 and 148·3 grs. respectively. Consequently the total weight of water (M) which is to be heated up in the first calorimeter is 4656·8 grs.; the total weight (M_1) in the second calorimeter 748·3 grs.

In this paper I shall always add to each item the figures obtained in the sixth test. What quantity P_1 (114·63 grs.) of the ammonia P (114·95) in tank IKL (capacity 242·05^{ccm}) was present in a liquid state, and what quantity $P - P_1$ (0·32) was present in a gaseous one, was calculated in the same way as μ_3 in I, p. 472.

If T is the temperature of the water in the first calorimeter at the commencement of the test (20°·69);

If T_1 is the temperature of the water in the first calorimeter at the end of the test (13°·82);

If $T_1 + \delta$ is the corrected temperature of the water in the first calorimeter at the end of the test (13°·5725);

If $T - (T_1 + \delta)$ is the number of degrees by which the water was cooled down (7°·1175);

If $\frac{T + T_1}{2}$ is the average temperature in the first calorimeter (17°·255);

If $\phi\, T$ is the tension of the ammonia vapor at $T°$ (6643$^{mm.}$);

If $\phi\, T_1$ is the tension of the ammonia vapor at $T_1°$ (5252$^{mm.}$);

If $\phi \frac{T + T_1}{2}$ is the average of both tensions (5947$^{mm.}$);

If τ is the temperature of the water in the second calorimeter at the commencement of the test (19°·11);

If τ_1 is the temperature of the water in the second calorimeter at the end of the test (18°·83);

If $\tau_1 + \delta_1$ is the corrected temperature of the water in the second calorimeter at the end of the test (18°·9816);

If $\tau - (\tau_1 + \delta_1)$ is the number of degrees by which the water was cooled down (0°·1284);

If $\frac{\tau + \tau_1}{2}$ is the average temperature in the second calorimeter (18°·97);

If ε is the mechanical equivalent of heat used under the prevailing circumstances by the gaseous ammonia for its expansion (317·4);

If c is the specific heat of gaseous ammonia (0·5084);

If C is the specific heat of liquid ammonia (1·22876).

The loss of heat, which both calorimeters together undergo, is

$$M[T - (T_1 + \delta)] + M_1[\tau - (\tau_1 + \delta_1)] = -33144{\cdot}8 - 96{\cdot}8 = -33241{\cdot}6 \text{ thermal units.}$$

But we have to make some corrections. There are to be subtracted:

(α) The quantity of heat s required by $P - P_1$ for changing its temperature from

$$T° \text{ to } \tau°; \; s = (P - P_1)\, c\, (T - \tau) = -0{\cdot}2$$

(β) The quantity of heat q_1 required by $P - P_1$ for expanding down to the atmosphere:

$$q_1 = \frac{10333\,(P - P_1)\,(273 + T)}{0{\cdot}7614\,.\,\varepsilon\,.\,273} = -9{\cdot}3$$

(γ) The quantity of heat s_1 required by P_1 for changing its temperature from

$$\frac{T + T_1}{2} \text{ to } \frac{\tau + \tau_1}{2}$$

after it had become a gas;

$$s_1 = P_1\, c \left(\frac{\tau + \tau_1}{2} - \frac{T + T_1}{2}\right) = -100{\cdot}0$$

There are to be added:

(δ) The quantity of heat s_2, which would have been

required by P_1, if it had been filled into the tank *IKL* at

$$\frac{T+T_1}{2}; \quad s_2 = P_1 C \left(T - \frac{T+T_1}{2}\right) = -387{\cdot}6$$

(ε) The quantity of heat q_2 required by P_1, in order to cool itself down to the temperature T_0, at which in reality it evaporates in tank *IKL*.

From the commencement of the evaporation, as soon as the gas begins to expand, the pressure prevailing in *IKL* ceases, being the one which corresponds to

$$\frac{T+T_1}{2} \text{ degrees,}$$

but it is lower. But if the pressure become lower, the temperature of evaporation must correspondingly become also lower, temperature and pressure of saturated vapor being dependent upon one another. Regnault, in determining the heat of evaporation of liquid carbonic acid, determined the decrease of temperature (y_1), which must be given to carbonic acid, in order to produce a cooling effect equal to the one produced, if it expands from a pressure of 1,000^{mm} above the atmosphere down to the atmosphere. This value y_1, not being known for ammonia, I determined it, entirely following the way used by Regnault, in determining y_1 for carbonic acid.

We first determine the decrease of temperature (y), which must be given to the unit of gaseous ammonia, in order to produce a cooling effect equal to the one produced if it expands from a pressure above the atmosphere ϕ down to the atmosphere, and from the so obtained value y we calculate the value y_1 for a pressure of 1,000^{mm} above the atmosphere.

Ammonia gas is developed in tank *A* (*Fig. 2*) and passes through the coils *FG* lying in the large tank *BCDE*, filled with water. At *a* the pipe enters the calorimeter *IKLM*. At *n*, the pipe of an inside diameter of 5^{mm} suddenly changes to a capillary tube, which at *o* changes again to a pipe of 5^{mm} diameter. An agitator in each tank keeps the temperature of the water equalized in all strata.

The ammonia, on entering the capillary tube at *n*, has the pressure corresponding to the temperature of the water in the large tank. On entering the wider tube at *o* and while passing through it, it expands down to the atmosphere. We admit that while passing through both tubes, the ammonia gas has the same temperature as the water in the calorimeter.

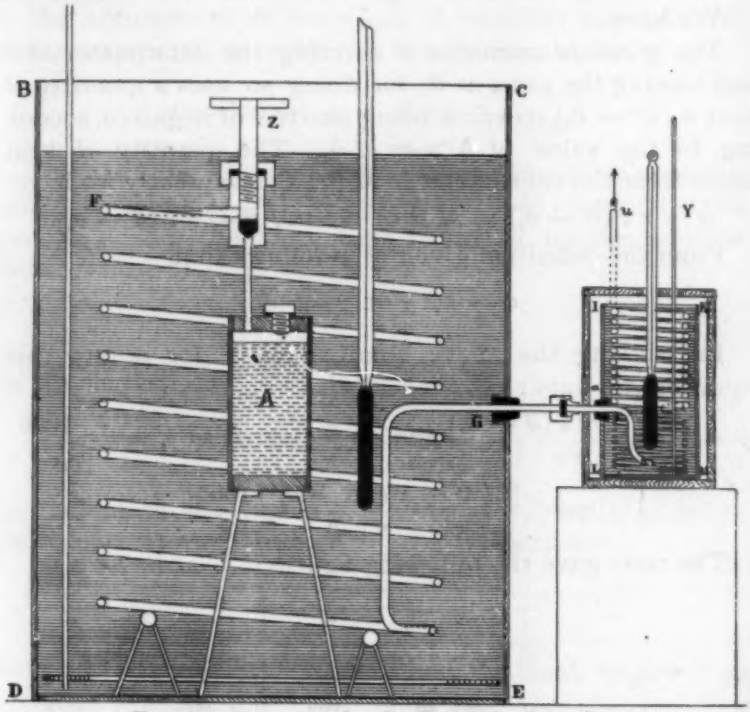


FIG. 2. Apparatus for the Determination of y_1.

If M = the total quantity of water which is to be heated up, consisting in each test of 767 or 768 grs. of water and 104 grs. value in water of the tank;

ϕ = the pressure above the atmosphere expressed in mm. of mercury, at which the evaporation of ammonia takes place;

π = the weight of the ammonia;

ϑ = the average temperature of the ammonia on entering the calorimeter;

ϑ_1 = the average temperature of the water in the calorimeter;

θ = the change of temperature which the water in the calorimeter underwent;

ω = the loss of heat caused by the ammonia by changing its pressure from ϕ to the atmosphere H;

c = the specific heat of gaseous ammonia = 0·5084.

We have:

The gaseous ammonia π entering the calorimeter at ϑ and leaving the same at ϑ_1, for doing so uses a quantity of heat $\pi c (\vartheta - \vartheta_1)$, its value being positive or negative, according to the value of $\vartheta >$ or $< \vartheta_1$. The quantity of heat taken from the calorimeter is $M \theta$. Consequently we have:

$$\omega + \pi c (\vartheta - \vartheta_1) = M \theta \text{ or } \omega = M \theta - \pi c (\vartheta - \vartheta_1).$$

From the definition given of y follows that

$$\omega = \pi c y \text{ or } y = \frac{\omega}{\pi c}$$

Introducing the above obtained value for ω into this equation, we have:

$$y = \frac{M \theta - \pi c (\vartheta - \vartheta_1)}{\pi c} \text{ and consequently as } y_1 = \frac{y \,.\, 1000}{\phi}$$

$$y_1 = \frac{[M \theta - \pi c (\vartheta - \vartheta_1)]\, 1000}{\pi c \phi}$$

The tests gave the following figures:

	1.	2.	3.	4.
ϕ, ...	5274·4 mm.	5259·2	5285·8	5441·6
π, ...	367·8 grs.	387·1	163·0	169·1
M, ...	871·0 grs.	871·0	872·0	872·0
ϑ, ...	18·563°	18·496	18·585	19·485
ϑ_1, ...	17·654°	14·996	19·325	18·871
$\vartheta - \vartheta_1$, ...	0·909°	3·500	− 0·840	0·614
θ, ...	− 1·538°	− 0·9887	− 0·7403	− 0·7303
$M\,\theta$, ...	− 1339·6 c.	− 861·2	− 645·3	− 636·6
$\pi c (\vartheta - \vartheta_1)$, ...	170·0 c.	688·8	− 69·6	52·7
ω, ...	− 1509·6 c.	− 1550·0	− 575·7	− 689·3
y, ...	− 8·07°	− 7·86	− 6·93	− 8·02
y_1, ...	− 1·530°	− 1·494	− 1·315	− 1·473

Taking the average, we obtain $y_1 = -1°{\cdot}453$.

We return now to p. 476ε. Even now we are not able to determine the temperature T_0 directly, but we can determine the pressure (f) at which the ammonia in tank IKL evaporated and from it figure the corresponding temperature T_0.

The gas P, as well that developed by the liquid P_1 as the gaseous one $P - P_1$, expands from the unknown pressure f to the atmosphere H, for which it requires a quantity of heat q_0 expressed, according to the above said, by

$$\text{equation (1)} \quad q_0 = P\, c\, y_1 \frac{f - H^2}{1000}$$

The gas P, by its passing through the second calorimeter under the pressure H, takes $M_1(\tau - (\tau_1 + \delta_1))$ thermal units from it, during the same time changing its temperature from

$$\frac{T + T_1}{2} \text{ to } \frac{\tau + \tau_1}{2}$$

for which purpose

$$P\, c \left(\frac{T + T_1}{2} - \frac{\tau - \tau_1}{2} \right)$$

thermal units are required. If the gas P, on its entering the second calorimeter, had had the temperature

$$\frac{\tau + \tau_1}{2}$$

which it has on leaving the same, the heat required q_0 would be expressed by

$$\text{equation (2)} \quad q_0 = M_1[\tau - (\tau + \delta_1)] + P_0 \left(\frac{T + T_1}{2} - \frac{\tau + \tau_1}{2} \right)$$

Now, if the calculated average pressure

$$\phi \frac{T + T_1}{2}$$

be the real prevailing one,

$$\phi \frac{T + T_1}{2}$$

must be equal to f. Thus by putting the value obtained for

$$\phi \frac{T + T_1}{2}$$

in equation (1) for f and by figuring up both equations for q_o, we must, of course, obtain the same value for q_o if our supposition

$$\phi \frac{T + T_1}{2}$$

to be equal to f be correct. Again, taking the figures obtained from the sixth test, we have

From equation (1) $q_o = -433{\cdot}3$

From equation (2) $q_o = -191{\cdot}4$

whence follows that f is not equal

$$\phi \frac{T + T_1}{2}$$

but smaller. If we introduce the value obtained from equation (2) for q_o into equation (1) and figure it up for f we have

$$f = \frac{1000 \cdot q_o}{y_1 P \cdot c} + T = 3018^{mm}$$

This was the real prevailing pressure at which the liquid in tank *IKL* evaporated.

The boiling point T_o, corresponding to this pressure, is $-0°{\cdot}06$. Consequently we have—

$$q_2 = P C \left(\frac{T + T_1}{2} - T_o \right) = -2446{\cdot}1$$

Thus, the total heat (Q) required by the quantity of ammonia (P), at a certain temperature

$$\frac{T + T_1}{2}$$

is

$$Q = M[T - (T_1 + \delta)] + M_1[\tau - (\tau_1 + \delta_1)] - s - q - s_1 + s_2 + q_2 = -35965{\cdot}8$$

or

The total heat (λ) required by the unit is

$$\frac{Q}{P} = -313{\cdot}7 \text{ thermal units.}$$

AUTHENTICAL PROOFS OF THE DETERMINATION OF THE HEAT OF EVAPORATION, ETC., OF LIQUID AMMONIA.

	1.	2.	3.	4.	5.	6.	AVERAGE.
P,	31'39	55'83	116'05	116'4	115'3	114'95	
$P - P_1$,	1'04	0'92	0'29	0'30	0'32	0'32	
P_1,	30'35	54'91	115'76	116'10	114'98	114'63	
M,	4656'8	4656'8	4656'8	4656'8	4656'8	4656'8	
$\phi\ T$,	5848	6506	6620	6313	6634	6043	
$\phi\ T_1$,	5525	5848	5264	4983	5135	5252	
$\phi\ \frac{T+T_1}{2}$	5686	6177	5942	5648	5885	5947	58[illegible] ; mm. or 7'71 atm. abs. press.
f,	2524	3374	2732	2989	3365	3018	298[illegible] mm. or 3'93 atm. abs. press.
T_o,	— 5'88	2'56	— 3'78	— 0'43	2'43	— 0'06	— 3'86° C. or 30°·45 F.
T,	17 19	20'13	20'64	19'30	20'68	20'69	
T_1,	15'20	16'60	13'70	12'31	13'74	13'82	
$T_1 + \delta$,	15'19	16'5143	13'3755	12'15536	13'40	13'5725	
$T - (T_1 + \delta)$,	— 2'00	— 3'6157	— 7'2645	— 7'14464	— 7'28	— 7'1175	
$\frac{T+T_1}{2}$	16'195	18'365	17'170	15'805	17'210	17'255	17° 00 C. or 62° 60 F.
$M\,[T - (T_1 + \delta)]$,	— 9313'6	— 16837'6	— 33829'3	— 33271'1	— 33901'5	— 33144'8	
ε,	317'4	317'4	317 4	317'4	317'4	317'4	
c,	0'5084	0'5084	0'5084	0'5084	0'5084	0'5084	
C,	1'22876	1'22876	1'22876	1'22876	1'22876	1 22876	
M_1,	748'3	748'3	748'3	748'3	748'3	748'3	
τ,	18'25	20'75	20'36	18'44	20'21	19'11	
τ_1,	18'13	20'55	20'17	18'43	20'08	18'83	
$\tau_1 + \delta_1$,	18'249	20'6882	20'2762	18'3849	20'13038	18'9816	
$\tau - (\tau_1 + \delta_1)$,	— 0'001	— 0'0618	— 0'0838	— 0'0551	— 0'07922	— 0'1284	
$M_1\,(\tau - [\tau_1 + \delta_1])$,	— 7'5	— 46'2	— 62'7	— 41'3	— 59'6	— 96'8	
$M_1\,[\tau - (\tau_1 + \delta)] + Pc\,\left(\frac{T+T_1}{2} - \frac{\tau+\tau_1}{2}\right)$	— 40'9	— 107'8	— 168'2	— 191'3	— 221'9	— 191'7	
$M\,[T - (T_1 + \delta)] + M_1\,[\tau - (\tau_1 + \delta_1),]$	— 9321'1	— 16883'8	— 33892'0	— 33312'4	33961'1	— 33241'6	
s,	— 0'6	— 0'3	— 1'0	— 0'1	— 0'04	— 0'2	
q_1,	— 47'2	— 40'6	— 13'0	— 13'5	— 14'4	— 9'3	
s_1,	— 30'8	— 63'1	— 181'7	— 153'2	— 169'6	— 100'0	
s_2,	— 29'7	— 95'3	— 394'3	— 399'5	— 391'4	— 387'6	
y_1,	— 1'453	— 1'453	— 1'453	— 1'453	— 1'453	— 1'453	
q_2,	— 823'1	— 1339'2	— 2986'6	— 2322'2	— 2093 8	— 2446'1	
Q,	— 10095'3	— 18214'3	— 37077'2	— 35867'3	— 36262'3	— 35963'8	
$\lambda = Q/P$,	— 332'6	— 331'6	— 310 8	— 308'9	— 315'1	— 313'7	— 318·8 French or — 573·8 English cal.
$q = q_2/P_1$,	— 27'1	— 19'4	— 25'8	— 20'0	— 18'2	— 21'3	— 22 0 " — 39 6
$r = \frac{Q - q_2}{P_1}$	— 305'5	— 312'2	— 285'0	— 288'9	— 296'9	— 292'4	— 296·8 " — 534·2

The heat of liquid (q) of the unit is

$$\frac{q_2}{P} = -21{\cdot}3 \text{ thermal units.}$$

The heat of evaporation (r) of the unit is

$$\frac{Q - q_2}{P} = -292{\cdot}4 \text{ thermal units.}$$

In the accompanying table, I give the figures obtained in the tests.

[*To be continued.*]

THE ACTION OF HYDROGEN SULPHIDE GAS UPON METALLIC AMINES.

BY EDGAR F. SMITH AND HARRY F. KELLER.

[*Read at the Stated Meeting of the Section, held October 21, 1890.*]

When pure, dry hydrogen sulphide gas was conducted over palladammonium chloride, Pd $(NH_3Cl)_2$, no change occurred in the appearance of the compound. However, on applying a gentle heat (70°–80° C.) to the boat containing the metallic amine, the latter gradually assumed a black color. This change extended throughout the entire mass. Upon increasing the heat ammonium chloride was volatilized. The residue was found to consist of palladium and sulphur. Single mineral acids were without effect upon it. Aqua-regia attacked it very slowly.

(I) — 0·3790 gram of Pd $(NH_3Cl)_2$ gave 0·2498 gram of the black sulphide. Assuming that the latter is represented by the formula PdS, the required monosulphide for the quantity of palladammonium chloride used would be 0·2484 gram.

(II) 0·2795 gram Pd $(NH_3Cl)_2$ gave 0·1822 gram sulphide, while the calculated amount should be 0·1831 gram.

This behavior of the palladammonium chloride led us to expose the following metallic amines to the action of hydrogen sulphide gas:

PURPUREO-COBALTIC CHLORIDE (Co_2Cl_6, $10NH_3$).—0·5287

gram of this substance, finely divided, were weighed out in a porcelain boat. The latter was placed in a combustion tube of hard glass. This was in connection, on the one side with a drying apparatus, on the other with a Peligot tube containing water. The latter served to produce a back-pressure of the gas, and in this manner the boat and its contents were constantly surrounded by an atmosphere of hydrogen sulphide. The gas was at first allowed to act in the cold. It produced an immediate change. The cobalt amine assumed an intense black color. To all appearances the change was complete in a few minutes, and extended through the entire salt. On the application of a gentle heat (80°) ammonium chloride volatilized. Later the heat was raised, and a current of carbon dioxide substituted for the hydrogen sulphide. The boat was allowed to cool down in this gas. The final product was dense, and black in color. Its weight was 0·2258 gram. Assuming the change of the amine was to sesquisulphide the amount of the latter, corresponding to 0·5287 gram of the amine, would weigh 0·2253 gram. On examining the sulphide it was found to consist of sulphur and cobalt.

ROSEO-COBALTIC SULPHATE ($Co_2(SO_4)_3, 10NH_3 + 5H_2O$).—This salt, too, sustained an immediate change when acted upon in the cold by hydrogen sulphide. There was in addition a simultaneous evolution of moisture, and stellated, colorless crystals appeared on the walls of the combustion tube. These gradually dissolved in the water present, and imparted to it an intense yellow color. The crystals were $(NH_4)_2S_2$. On gently heating roseo-cobaltic sulphate in a stream of hydrogen sulphide, it invariably happened that when a temperature of 70° C. was attained, the black mass, in the boat, swelled up considerably, and was projected into the tube. Some deep-seated change occurred, which we are not prepared to explain at present.

LUTEO-COBALTIC CHLORIDE ($Co_2Cl_6, 12NH_3$).—This salt was affected by hydrogen sulphide in the cold, although heat was required to bring about a complete change. One quantitative determination gave the same result as was obtained

with purpureo-cobaltic chloride, *i. e.*, the product was evidently cobalt sesquisulphide.

Of the cobalt amines examined, the roseo-derivative was most rapidly changed by the gas. We have good reasons for believing that we can make this reaction serviceable in the determination of cobalt in these bases.

PURPUREO-CHROMIC CHLORIDE ($Cr_2Cl_6,10NH_3$).—We exposed this salt for a long period, in the cold, to the influence of hydrogen sulphide, without its sustaining any alteration. On raising the temperature so that it was slightly lower than the dissociation temperature of hydrogen sulphide, the purple-colored amine became quite black in color. It had a velvety appearance and resembled the chromium sesquisulphide obtained by other methods.

(I) 0·6390 gram substance gave 0·2640 gram sulphide. The theoretical amount should be 0·2629 gram.

When this sulphide is exposed to a high heat in a current of hydrogen gas, it parts very slowly with its sulphur.

It is our intention to apply this reaction to other metallic amines as soon as we can do so, though at present our work has been interrupted by unforeseen circumstances.

UNIVERSITY OF PENNSYLVANIA,
PHILADELPHIA, October 17, 1890.

ALLOYS OF SODIUM AND LEAD.

BY WM. H. GREENE AND WM. H. WAHL.

[*Read at the Meeting of the Chemical Section, November 18, 1890.*]

Recently, in the course of certain investigations, in which we had occasion to make use of alloys of lead and sodium, we found that the properties of such alloys did not correspond with what we had anticipated from previous publications on the subject, and we were led to an examination of the properties of lead-sodium alloys of definite composi-

tion. These alloys may easily be made by direct combination, and the products are then sensibly constant in composition, which is not the case when they are prepared by reducing lead oxide by carbon in presence of soda, or by heating litharge with sodium tartrate, as described by Vanquelin and Serullas.

The required quantity of sodium was added to lead melted in a covered crucible, and the alloy was roughly analyzed by determining lead only. Our alloys contained from three to thirty-one per cent. sodium. They are all brittle and crystalline; all decompose water, that containing the least sodium producing a hardly perceptible evolution of gas, while that containing thirty-one per cent. reacts with violence. The brittleness and oxidability increase with the percentage of sodium. The richest alloy is greenish in color and instantly blackens on exposure to air.

We made special examinations of the alloys corresponding in composition to Na_2Pb_2, Na_2Pb and Na_4Pb: the first of these contained ten per cent. sodium, the second 19·5 per cent, rather more than would be indicated by the formula, while the last contained 31·7 per cent. The densities were determined in aniline and found to be considerably higher than would be the densities of mixtures of the same composition. Thus the ten per cent. alloy has a density of 6·91, the 19·5 per cent. a density of 4·61, and the 31·7 per cent. alloy a density of 3·81. The densities of corresponding mixtures would be 5·6, 3·7 and 2·7, respectively.

The theoretical and calculated percentages of Na in alloys of above assumed composition compare as follows:

	Pb_2Na_2	Pb_2Na	Pb_4Na
P.C.Na by theory, ...	10	18·18	30·8
" found, ...	10	19·5	31·7

A NEW PHOTOGRAPHIC PROCESS WITHOUT METALLIC SALTS.

This process was presented at the recent meeting of the British Association for the Advancement of Science, by Mr. A. G. Green, and his co-laborers, Messrs. Cross and Bevan, in a paper detailing highly successful experiments with primuline for producing designs on cotton, linen or silk cloths, on paper, and, by aid of gelatine, on glass, etc., by a "photographic method of dyeing and printing." The process requires no longer time of exposure than that with silver salts, whilst it has a more general range of sensitiveness in the spectrum, and at the same time affords the choice of a great variety of colors for the finished prints; and as primuline is a commercial article used on a large scale, it is comparatively inexpensive. The process will only be outlined in brief. Primuline, a coal-tar product, is an amido-sulphonic acid discovered by Mr. Green, in 1887, and named by reason of the primrose yellow color imparted by it to cotton in alkaline solution, without a mordant. It has been quite extensively used for producing a great variety of colors in cotton cloth by *diazotizing* the compound in the cloth dyed with primuline, by passing it through a weak solution of nitrous acid, or rather of a nitrite with an acid, and thus imparting to it the property of combining with various phenols or amines to produce in the fabric a variety of highly colored, very fast dyes—the so-called in-grain colors, the particular color in any case being determined by the phenol or amine employed in solution rendered acid or alkaline as may be necessary. It was found that the diazotized compound is extremely sensitive to light, which destroys this property of combining with the phenols and amines, so that a fabric dyed with primuline, then washed and treated with nitrite of soda and acetic acid, and again washed, and then exposed, either moist or dry under any design, as a drawing or a negative, will lose

the property of becoming dyed by the phenols and amines in the parts acted upon by light, so that in a subsequent treatment with a suitable amine or phenol, as a developer, only the protected parts will become dyed, and a print will be produced having the positive or negative character of the original. Thus the lines of a drawing will be reproduced in color. By selection of the suitable developer not only one of a great variety of colors may be given, but by applying two developers, mixed with starch paste locally by means of a brush, two colors may be produced in the same fabric. The fixing of the print is accomplished by simply washing it with water. The following developers were given: For *red*, an alkaline solution of beta-naphthol; for *maroon*, of beta-naphthol-disulphonic acid; for *yellow*, of phenol; for orange, of resorcin; for *brown*, a solution of phenylene-diamine hydrochloride; for *purple*, a solution of alpha-naphthylamine hydrochloride. Paper for copying plans, etc., may be coated by means of a brush or roller. The process is in its tentative stage and full of promise in many directions. According to an article in the *British Journal of Photography*, based on further experiments, and giving working formulæ, the dressing should be removed from ordinary muslin for use by this process; the exposure required is less than with ordinary albumenized paper, but negatives of greater density are required; and, what is of highest interest, a simple aqueous solution of either of the common photographic developing agents, eikonogen and pyrogallol, will act as an energetic developer, the former giving the much desired ink-black tone and the latter a brown tone. C. F. H.

NOTES AND COMMENTS.

MECHANICS.

THE MANNESMANN TUBES.—At the stated meeting of the Institute, for the month of November, 1890, the secretary exhibited a number of specimens of tubes (and of special forms made from the same), rolled by the method invented and developed industrially by the brothers Reinhard and Max Mannesmann, of Remscheid, Germany, and described the process of manufacture and the uses of the products. The following abstract of a paper descriptive of a similar exhibit made by Dr. Hermann Wedding at the International Meeting of Engineers, lately held at Pittsburgh, is reproduced from the *American Manufacturer*:

"* * * The exhibit was most interesting from an engineering point of view, marking, as the invention does, an epoch in the mechanical department of the metallurgy of iron and steel, and being one of the most radical innovations ever made in the methods of mechanically manipulating metal.

"More or less has already been published concerning the process and the appliances used in the production of these tubes, though of the importance which the manufacture has already assumed, the rapidly increasing capacity of the plants engaged in their production, and the great measure of success which has already attended their manufacture and use, comparatively little has heretofore been made public in this country. It is of these last-named features with which this article will have principally to deal. And while to give a description of the method of manufacture may seem superfluous, a brief sketch of the process may not be out of place in this connection.

"The method is of special use in the making of pipes designed to withstand heavy pressures, and must be regarded as an important improvement. It is a departure from previous practice in such manufacture well calculated to work a revolution in the methods of manufacturing, as well as the results obtained, which are most remarkable. The process consists in feeding a solid, heated bar of ingot metal between rolls, which, while their axes are oblique to the axis of revolution, revolve both in the same direction. The metal of the surface of the bar thus acquires an increased motion in a spiral direction, and is drawn over its core, receiving consequently the form of a pipe. Since, in this operation, the pipe moves spirally forward, and all its parts are spirally pushed and pressed the metal becomes still denser. It is this spiral arrangement of the metal which makes the Mannesmann pipes so remarkable, quite apart from the advantage they possess in presenting no lines of welding whatever. Moreover, blowholes (which are invariably present in ingot iron), are so squeezed out spirally as to make the walls of the pipe completely impermeable. A proof of this is the retention of hydrogen for weeks in a piece of Mannesmann pipe, closed at both ends. Pipes thus made and enlarged have been successfully produced of all diameters up to eighteen inches.

"A serious obstacle which had to be overcome by special design of machinery lay in the excessive unit stresses in the teeth of common gearing when transmitting very high powers at high rates of speed. Likewise special coupling for the different parts of the machinery had to be devised for the various parts of the machinery. A special form of fly-wheel for the steam engines used was devised, being built up of steel discs with a rim of wire under high initial tension, cast-iron wheels being entirely unsuitable for the high speeds at which it is necessary to run the engine. The details of construction of much of this special machinery has been kept a secret with the manufacturers.

"In addition to the rolls in making the tubes, a mandrel may be used, improving the product, in that the pipe is at once made smooth and more nearly perfect inside than would be the case otherwise.

"The proportion of the inside diameter or bore of the tube may be varied within wide limits. In work thus far done, it has been possible to make a tube, say of one and one-half inches outside diameter, with a bore not larger than a small wire, say one-sixteenth of an inch, and in contrast to such tubes, pipes are regularly made by this process having an area of bore equal to ninety-five per cent. that of the outside measurement, and even this, it is claimed, may be readily exceeded if occasion should demand, as experiments which have been made clearly demonstrate.

"The pipes are made in the ordinary length, eighteen to twenty-three feet; they have, however, been turned out in lengths of forty-five feet and upwards, thus insuring a considerable decrease in the number of connecting pieces required.

"One use to which these tubes seem specially adapted, large numbers of them having already been placed on the market for that purpose, is for carbonic-acid reservoirs, their great strength and comparative lightness peculiarly fitting them for this purpose. They are made from one piece hammered together at both ends, thus entirely avoiding welded bottoms; tubes made in this manner have been tested up to 300 atmospheres (4,500 pounds) per square inch, and it is claimed as perfectly feasible to make them capable of withstanding a pressure of 16,000 pounds per square inch.

"Their use in the natural gas and petroleum industries will suggest itself, as well as for transmitting power long distances by means of compressed air, from what has already been said concerning their adoption in Europe for similar purposes.

"It has been found possible to roll a tube of a given length with the walls thicker at middle than at the ends, and then by making such tubes of rectangular or other desired section by re-rolling, to produce beams or girders of constant strength throughout their entire length, this being effected by making the billet from which the tube is to be rolled of less section in the middle than at the ends in the beginning of the process. It will be seen that by this means of producing beams, girders or other structural shapes, the maximum of strength may be obtained with a given amount of metal, in some structures, railway bridges and roof trusses for instance, an important consideration, and a use to which the product may be put. And the ordinary tube of cir-

cular section presents many advantages as structural material, by reason of the qualities of strength and lightness set forth above.

"The samples of these square and other profiles of what may be termed tube-rails prove the possibility of turning out Mannesmann-tubes in almost any desired form, which, if done, adds much to the available working material for the constructing engineer, and this feature of the manufacture and the product has been quite fully dwelt upon by various prominent engineers, among whom may be named Messrs. Frederick Siemens, J. G. Gordon, Profs. Angstrom, Wedding, Reuleaux and Von Hofer, who have, in papers read before engineering societies, described the merits and probable uses of this new form of structural material. Prof. Reuleaux has said of it in an address: 'It is undoubtedly true that we have in the Mannesmann process an epoch-making invention; it is certain to bring about a great change in rolling mills; it has, indeed, already a deep influence on rolling processes. The energy and untiring perseverance with which the inventors have worked out their plans and put them into actual use deserves our warmest appreciation.' The other engineers above named, all of them of unquestioned ability, have announced their confidence in and appreciation of the new invention in no less forcible terms than Prof. Reuleaux, just quoted.

"The tests to which some of the tubes exhibited had been submitted were most severe in their character, and fully showed the superiority of tubes of this method of manufacture over those made in the ordinary process of welding. Tests of compression and expansion from internal pressure have already been mentioned, but the distinctive characteristics of the Mannesmann tubes were, if need be, more fully shown by the torsional tests which had been applied. Specimens of these tubes were shown which had been bent, rolled and twisted in almost all conceivable shapes, but without destroying the tube or breaking or even cracking its walls, all of the tests being of a nature which would hopelessly have destroyed a welded tube of ordinary manufacture. [Some of the shapes into which these tubes have been bent and twisted were shown.]

"The use of Mannesmann tubes for all purposes where great strength, combined with lightness and absolute homogeneity of metal, as for car axles and similar uses, has been suggested. It has been found in the experiments which have been made that an inferior metal, one not perfectly homogeneous in its composition and quality, will not stand the test of being put through the Mannesmann rolls, that it is entirely impossible to form a tube out of imperfect material. This being the case, the very fact that a tube has been formed by this method is of itself at once a guaranty of the quality of the material used, and gives in the product a degree of safety in use never before attained.

"Regarding the physical structure of tubes made by this process, Dr. Wedding has found, in the examinations he has made with the microscope, that the metal shows a very distinct spiral structure. The tubes of cast steel have a number of extremely minute gas bubbles which wind through the metal, following closely the direction of the fibres. The presence of these

spaces does not appear materially to affect the strength of the pipe, since the tests show more than double the strength of similar wrought-iron tubes.

"At present there are four manufactories of these tubes, all of them being in Europe. Arrangements are being perfected by which the manufacture will be begun in this country, American capital to be enlisted for that purpose. The foreign works now in operation are located at Remscheid, Germany; one at Kotomau, Bohemia; a small works at Bous, Germany, and a large works at Landore, Wales, operated by the Mannesmann Tube Company."

BOOK NOTICES.

ELECTRO-CHEMICAL ANALYSIS. By Edgar F. Smith, Professor of Analytical Chemistry, University of Pennsylvania. (With twenty-five illustrations.) Philadelphia: P. Blakiston, Son & Co., 1012 Walnut Street. 1890.

The electrolytic process, as applied to the quantitative estimation of metals (principally of copper), until lately has been confined to the field of the assayer, and chemists as a body hitherto have practically ignored a method which, when intelligently employed, has been shown to be capable of comparing in accuracy with the most refined gravimetric and volumetric methods. It is, indeed, surprising that a field of work so inviting to the investigator, and which has yielded such splendid results in the hands of technical chemists, should have remained so long neglected. This reproach, happily, is in fair way to be removed, since the electrolytic method has of late attracted the thoughtful attention of a number of able investigators, through whose labors its value as an aid in analytical work has been fully demonstrated, and the scope of its applicability greatly widened, so that at present—thanks to the investigations of Classen, v. Reiss, Luckow, Smith, and others—it is receiving at the hands of instructors in chemistry the recognition to which it is entitled, of a place, side by side, with the older and standard gravimetric and volumetric methods.

Prof. Smith's little volume is a timely and useful addition to the list of text-books on this subject and will be particularly welcome to English and American students, for the reason that it brings the applications of the electrolytic method down to the present, showing incidentally how rapidly its scope has been extended, and supplements Classen's work on the subject, which hitherto has been the only one, in English, treating specially thereon.

Prof. Smith's volume is arranged with the special object of serving as a guide for the student, and the preliminary chapters, relating to the action of the electric current on acids and salts, the electric units, the sources of electric current, methods of regulating and measuring currents, are well adapted to his requirements.

The special part of the volume describes the methods employed for the quantitative determination of metals by electrolysis for the separation of metals from each other and their quantitative estimation by electrolysis, and for effecting oxidations by means of the electric current. A number of the processes therein described have originated with the author, who is well known as an able and indefatigable investigator in this domain. W.

CORRESPONDENCE.

To the Committee on Publications:

How to measure any angle without a protractor, or without trigonometrical tables has not to my knowledge been given anywhere.

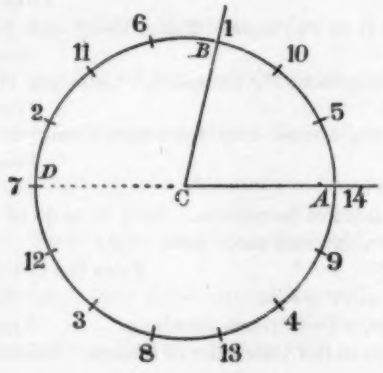
The following is my method, the accuracy of which is limited only by the skill of the operator.

Let it be required to measure the angle *A C B*.

Describe a circumference of radius *C A* and carry the chord *A B* around the circumference, several times if necessary, until one point of the dividers coincides with the point *A*.

In the case illustrated, this occurs after going around the circumference three times with fourteen steps of the dividers. The required measure is, therefore, $\frac{3}{14}$ of 360° or $77\frac{1}{7}$°.

The method, it is seen, consists simply in finding graphically a known arc which is an exact multiple of the arc to be measured.



In the case just considered the known arc is three times 360°; but, of course, it need not be a multiple of 360°, it may be one of 180° for instance. Producing the radius *A C* to *D* we find that seven steps of the dividers are exactly three times 180°, which gives as before for the required measure $77\frac{1}{7}$°.

It is, therefore, advisable in practice to increase the chances of obtaining a coincidence by dividing up the circumference into arcs of known value. The division into six equal parts is suggested as the simplest.

In cases where an exact coincidence is not obtainable, but one is assumed, the error made is divided by the number of steps taken by the dividers. This must happen whenever the angle to be measured is incommensurable.

JOSEPH BECKER.

WASHINGTON, November 1, 1890.

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Franklin Institute

[*Proceedings of the Stated Meeting, held Wednesday, November 19, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 19, 1890.

JOS. M. WILSON, president, in the Chair.

Present, 172 members and thirty-four visitors.

Additions to membership since last month, twenty-one.

The secretary presented letters from Prof. E. Mascart, of Paris, Col. Turrettini, of Geneva, and Prof. W. Cawthorne Unwin, of London, accepting election as honorary members of the Institute; from General A. W. Greely, Chief Signal Officer, in response to the official letter of the secretary transmitting the thanks of the Institute, expressing gratification on behalf of himself, Captain H. H. C. Dunwoody, and Sergeant T. F. Townsend, of the Signal Office, that the policy of the service has merited the approbation of the Institute, and the assurance of continued co-operation in the work of the State Weather Service; and from M. W. Grosseteste, Engineer of Mulhouse, presenting to the Institute a copy of a medal and a pamphlet prepared as a manifestation of honor to the late M. Gustav Adolph Hirn. In reference to the last communication, the gift was accepted with thanks, and the secretary was directed to acknowledge the courtesy of M. Grosseteste and his colleagues, and to convey to him and them a suitable expression of the high appreciation with which the members of the Franklin Institute esteem the scientific work of M. Hirn, which has added so much to our knowledge of the action of heat in the steam engine.

In the absence of Mr. F. Lynwood Garrison, the secretary presented a brief abstract of his paper announced for the evening, on the manufacture of tin-plate. (Referred for publication.)

Mr. Wm. B. LeVan read a paper, illustrated by numerous diagrams and specimens, on the proper method of making joints in steam-boilers. The paper was discussed by Messrs. Fullerton, Christie, Wiegand and the author. (Referred for publication.)

Mr. W. N. Jennings exhibited a series of photographic views on the screen, including several highly interesting pictures of lightning flashes, and commented briefly upon the same.

The secretary's report embraced a description of the process of the Mannesmann Brothers, for rolling seamless tubes of steel from the ingot, with the exhibition of a suite of remarkable specimens; an abstract of the report of the Committee on Science and the Arts on the product of the Eureka Tempered Copper Company, with the exhibition of a large variety of samples; and a description of two of the most recently devised machines of the matrix type, for casting type-bars for printing. These machines are designed to do away with the setting up of type by hand. The machines specially described were the improved linotype of Mr. Ottmar Mergenthaler, of New York, and the typograph devised by John R. Rogers, of Cleveland.

Adjourned.

WM. H. WAHL, *Secretary.*

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR MAY, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 31, 1890.

TEMPERATURE.

The mean temperature of 59 stations for May, 1890, was 58°·8, which is about 1° below the normal.

The mean of the daily maximum and minimum temperatures 69°·6 and 47°·4 give an average daily range of 22°·2, and a monthly mean of 58°·5.

Highest monthly mean, 63°·9 at Arnville.

Lowest monthly mean, 52°·5 at Eagles Mere.

Highest temperature recorded during the month, 89° on 31st, at Wilkes-Barre.

Lowest temperature, 23° on the 1st at Nisbet.

Greatest local monthly range, 31°·7 at Selins Grove.

Least local monthly range, 15° at Eagles Mere.

Greatest daily range, 48° at Lewistown on 13th.

Least daily range, 1° at Le Roy on 30th.

From January 1, 1890 to May 31, 1890, the excess in temperature at Philadelphia was 650°, and at Erie 383°.

BAROMETER.

The mean pressure for the month, 29·96, is about normal. At the U. S. Signal Service Stations, the highest observed was 30·31 at Philadelphia on the 22d and the lowest 29·60 at Harrisburg on the 5th.

PRECIPITATION.

The average precipitation, 6·71 inches, is an excess of three and one-half inches. Rains were of almost daily occurrence in some parts of the state. The 17th, 28th and 29th were the only days on which no rain was reported The largest monthly totals in inches were: Girardville, 12·41; Emporium, 9·61; Eagles Mere, 8·97; Somerset, 8·90; Mauch Chunk, 8·11; Gettysburg, 8·10, and Uniontown, 8·03. The least was Philadelphia, 2·96.

WIND AND WEATHER.

The prevailing wind was from the west. On the 10th, about 5 P.M., a tornado passed over the southern part of Franklin County, doing considerable damage. The weather during the month was excessively wet. The ground was saturated and cold, and caused much delay in plowing and seeding. Average number: Rainy days, 15; clear days, 7; fair days, 11 cloudy days, 13.

MISCELLA[illegible]OUS PHENOMENA.

Thunder-storms.—Get[illegible]burg, 13th, 14th, 19th; Charlesville, 1st, 3d, 5th, 23d, 30th; Blue K[illegible], 5th, 10th, 11th, 13th, 19th, 20th, 23d, 24th, 25th, 26th; Hollidaysburg, 13th, 14th, 19th, 23th, 25th, 30th; Tipton, 10th, 13th, 14th, 18th, 23d, 25th, 30th; Le Roy, 13th, 14th; Forks of Neshaminy, 13th, 14th; Quakertown, 1st, 4th, 13th, 14th, 20th; Johnstown, 13th, 14th, 18th, 23d, 24th, 25th; Emporium, 3d, 10th, 13th; Mauch Chunk, 13th, 14th, 19th, 20th; State College, 5th, 13th, 14th, 18th, 23d, 30th; Phillipsburg, 23d; West Chester, 1st, 13th, 14th; Coatesville, 1st, 4th, 13th, 14th, 20th; Westtown, 13th, 16th, 19th; Rimersburg, 10th, 18th, 23d, 24th, 25th; Clarion, 3d, 4th, 9th, 24th, 25th, 30th; Lock Haven, 5th, 13th, 14th, 25th; Catawissa, 14th, 19th; Meadville, 3d, 5th, 10th, 13th, 18th, 22d, 23d, 24th, 25th, 30th; Carlisle, 1st, 13th, 19th, 25th; Harrisburg, 14th, 19th, 25th; Swarthmore, 2d, 13th, 14th, 16th; Uniontown, 10th, 15th, 18th, 23d, 24th, 30th; Chambersburg, 1st, 19th, 30th; Huntingdon, 13th, 14th, 19th, 23d, 26th, 30th; Petersburg, 5th, 13th, 23d; Lancaster, 1st, 13th, 14th, 19th, 25th; Myerstown, 1st, 13th, 14th, 19th, 20th, 26th; Annville, 1st, 13th, 14th, 18th, 19th, 20th, 23d, 25th, 26th; Scranton, 14th, 19th, 20th; Wilkes-Barre, 13th, 14th, 19th; Lewistown, 1st, 13th, 14th, 18th, 23d, 30th; Philadelphia, 1st, 13th, 14th, 16th; Girardville, 4th, 14th, 19th; Selins Grove, 5th, 14th, 15th, 18th, 19th; Somerset, 11th, 15th, 24th, 26th, 27th; Wellsboro, 5th, 10th, 12th, 25th; Lewisburg, 6th, 13th, 14th, 18th, 19th; Columbus, 3d, 10th, 18th, 25th; Dyberry, 13th, 14th, 19th; Ligonier, 23d; South Eaton, 14th, 19th, 20th; York, 13th, 23d.

Hail.—Gettysburg, 1st, 19th; Charlesville, 25th; Blue Knob, 30th; Hollidaysburg, 13th; Tipton, 23d; Quakertown, 24th; Mauch Chunk, 19th; Coatesville, 1st; Petersburg, 13th; Lewistown, 13th; Philadelphia, 1st; Somerset, 24th; Lewisburg, 14th; York, 2d.

Snow.—Blue Knob, 7th.

Frost.—Gettysburg, 12th, 17th; Charlesville, 17th; Blue Knob, 2d, 7th, 8th, 16th, 18th, 21st; Hollidaysburg, 2d; Tipton, 2d, 7th, 12th, 17th, 18th, 28th; Le Roy, 2d, 8th, 12th, 18th, 21st; Quakertown, 2d, 7th, 9th, 17th; Emporium, 2d, 12th, 18th; State College, 2d, 18th; Phillipsburg, 2d; West Chester, 9th; Coatesville, 9th; Rimersburg, 2d, 8th, 18th, 21st; Grampian Hills, 2d, 7th; Lock Haven, 7th, 12th; Catawissa, 2d, 7th, 12th; Meadville, 2d, 7th, 8th, 18th, 21st, 28th; Carlisle, 7th, 12th, 17th; Uniontown, 2d, 8th, 13th, 18th; Huntingdon, 7th, 12th; Petersburg, 2d, 7th, 12th; Myerstown, 2d, 17th; Wilkes-Barre, 2d, 7th; Nisbet, 1st, 7th, 12th, 17th, 18th, 28th; Lewistown, 2d; Philadelphia, 9th; Girardville, 2d, 9th, 17th, 18th; Selins Grove, 2d, 8th, 12th, 28th; Somerset, 13th, 18th, 19th, 29th; Eagles Mere, 2d, 7th; Wellsboro, 2d, 3d, 7th, 8th, 9th, 11th, 21st, 28th; Lewisburg, 7th, 12th; Columbus, 2d, 7th, 8th, 12th, 18th; Dyberry, 2d, 3d, 7th, 9th 12th, 17th, 18th; Honesdale, 2d, 3d, 9th, 12th; South Eaton, 2d, 9th; York, 7th, 9th.

Sleet.—Wellsboro, 20th.

Coronæ.—Charlesville, 30; Annville, 29th; Lewistown, 2d, 24th; Dyberry, 28th.

Solar Halos.—Le Roy, 2d, 3d, 9th, 21st; Meadville, 16th; Eagles Mere, 9th; Wellsboro, 9th, 18th, 29th; Dyberry, 3d, 8th, 9th, 27th.

Monthly Summary of Reports of Voluntary Observers of the Pennsylvania State

County.	Station.	Elevation above Sea Level (feet).	Barometer Reduced to Sea Level.			Temperature.												Relative Humidity.
			Mean.	Highest.	Lowest.	Mean	Maximum.		Minimum.		Mean of Maximum.	Mean of Minimum.	Daily Ranges.					
							Highest.	Date.	Lowest.	Date.			Mean.	Greatest.	Date.	Least.	Date.	
Adams,[1]	Gettysburg,	624	. . .	. . .	. . .	59·6	83·0	1	32·0	2	75·6	45·0	25·6	38·0	13	3·0	6	. . .
Allegheny,[1]	Pittsburgh,	847	29·950	30·090	29·630	62·0	86·0	30	37·0	2	71·4	52·5	18·9	36·0	18	9·0	7	81·8
Bedford,	Charlesville,	1,300	. . .	. . .	. . .	57·4	82·0	13	28·0	2	70·2	42·0	28·2	42·0	12	7·0	7	79·9
Berks,[1]	Reading,	304	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Blair,[2]	Altoona (29 days),	1,181	. . .	. . .	. . .	61·6	80·0	14	35·0	2	74·0	52·2	21·8	36·0	2	10·0	23	55·1
Blair,	Blue Knob,	2,500	. . .	. . .	. . .	57·1	83·0	13	30·0	2	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Blair,	Hollidaysburg,	947	. . .	. . .	. . .	60·0	84·0	13	29·0	2	72·0	46·0	26·0	44·0	12	6·0	26	81·0
Blair,	Tipton,	915	. . .	. . .	. . .	58·2	85·0	31	33·0	2, 3	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Bradford,	Wysox,	718	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Bradford,	Le Roy,	1,400	. . .	. . .	. . .	55·4	77·0	14, 24	30·0	2	64·0	46·9	17·1	35·0	12	1·0	30	. . .
Bucks,	Forks of Neshaminy,	. . .	. . .	. . .	. . .	60·7	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Bucks,	Quakertown,	536	29·680	30·280	29·600	50·0	80·7	19	31·0	9	70·8	46·9	23·9	37·0	31	12·0	4	76·6
Bucks,	Hulmeville,	120	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Cambria,[1]	Johnstown,	1,184	29·936	30·273	29·585	59·5	82·0	13	33·0	2	71·1	47·8	23·3	38·0	18	9·0	26	80·7
Cameron,	Emporium,	1,030	. . .	. . .	. . .	59·5	81·0	13, 29	28·0	2	70·0	44·8	25·2	46·0	3	9·0	14	. . .
Carbon,[1]	Mauch Chunk,	550	. . .	. . .	. . .	58·4	79·0	1, 14	30·0	9	70·5	46·4	24·1	39·0	9	7·0	4	. . .
Centre,	State College— Agricultural Experiment Station,	1,19…	29·917	30·231	29·521	57·6	76·0	29	27·0	2	66·8	47·0	19·8	37·0	3	5·0	26	74·8
Centre,	Phillipsburg,	1,350	. . .	. . .	. . .	55·6	83·0	13	25·0	2	69·1	44·7	24·4	45·0	12	6·0	4	. . .
Chester,	West Chester,	455	29·965	30·288	29·596	60·3	82·5	1	35·0	2	70·3	51·0	19·3	29·5	1	11·0	25	72·0
Chester,	Coatesville,	380	. . .	. . .	. . .	60·5	84·0	1	33·0	9	72·9	49·0	23·9	35·5	9	10·0	4	. . .
Chester,[1]	Kennett Square,	275	. . .	. . .	. . .	61·0	74·0	13	42	2, 3	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Chester,	Westtown,	550	29·93…	…268	29·591	60·9	81·5	1	…6	9	70·6	51·5	19·1	30·5	9	11·5	27	. . .
Clarion,	Rimersburg,	1,500	. . .	. . .	. . .	56·7	88·0	30	36·0	1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Clarion,	Clarion— State Normal School,	1,530	. . .	. . .	. . .	56·8	80·0	24	29·0	7	65·7	44·0	20·8	35·0	31	11·0	14	78·3
Clearfield,	Grampian Hills,	2,450	. . .	. . .	. . .	57·1	80·0	24, 30	28·0	2	67·5	47·8	19·7	38·0	12	2·0	6	. . .
Clinton,	Lock Haven,	560	. . .	. . .	. . .	59·0	80·0	24	29·0	2	69·0	46·0	23·0	38·0	12	6·0	25	. . .
Columbia,	Catawissa (27 days),	491	. . .	. . .	. . .	58·7	78·5	13	33·0	2	68·5	49·0	19·5	. . .	. . .	. . .	. . .	. . .
Crawford,	Meadville,	1,220	. . .	. . .	. . .	53·5	78·5	30	30·0	2	64·6	44·0	20·6	34·0	3	9·0	5	80·2
Cumberland,	Carlisle,	480	. . .	. . .	. . .	60·1	83·0	1, 13	34·0	11, 12	72·9	48·8	24·1	41·0	12	7·0	25	56·…
Dauphin,[1]	Harrisburg,	361	29·982	30·290	29·600	60·4	79·0	13	38·0	2	70·0	51·6	18·4	30·0	17	9·0	25	66·…
Delaware,	Swarthmore— Swarthmore College,	190	29·963	30·260	29·604	60·9	82·0	19	38·5	2, 9	71·9	56·1	15·8	29·5	9	10·0	25	7…·0
Erie,[1]	Erie,	681	29·930	30·300	29·611	53·0	79·0	25	34·0	2	62·0	45·0	17·0	35·0	3	6·0	6	3…·0
Fayette,	Uniontown,	1,000	29·937	30·199	29·653	62·4	86·0	29	34·0	2	73·3	49·4	23·9	45·0	18	9·0	20	. . .
Forrest,	Tionesta,	1,057	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Franklin,[1]	Chambersburg— Wilson Female College,	618	29·972	30·209	29·625	59·8	82·0	13, 14	30·0	1…	72·0	46·1	25·9	41·0	12	10·0	26	83·0
Fulton,	McConnellsburg,	875	. . .	. . .	. . .	60·4	80·0	13, 30	34·0	2	70·9	48·9	22·0	36·0	17	4·0	25	78·…
Greene,	Waynesburg,	750	. . .	. . .	. . .	63·4	86·0	30	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Huntingdon,[1]	Huntingdon— The Normal College,	690	. . .	. . .	. . .	58·5	88·0	13	31·0	2	71·5	53·3	18·2	42·0	12	4·0	26	. . .
Huntingdon,	Petersburg,	700	. . .	. . .	. . .	57·6	88·0	31	30·0	2	68·9	46·7	22·2	39·0	18	7·0	25	. . .
Indiana,	Indiana— State Normal School,	1,350	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Lackawanna,[1]	Scranton,	. . .	. . .	. . .	. . .	58·4	78·0	24	32·0	8	67·5	49·3	18·2	36·0	1	6·0	1	69·8
Lancaster,	Lancaster,	411	29·976	30·263	29·457	60·3	80·0	14	34·0	2	71·0	49·8	21·2	33·1	12	6·9	25	86·3
Lawrence,	New Castle,	832	. . .	. . .	. . .	62·6	85·0	30	26·0	2	72·3	45·1	27·2	46·0	2	13·0	19	. . .
Lebanon,	Myerstown,	474	29·940	30·241	29·582	59·8	82·0	6	32·0	9	71·6	47·4	24·2	37·0	9	9·9	4	79·1
Lebanon,	Annville— Lebanon Valley College,	330	. . .	. . .	. . .	63·9	85·0	19	42·0	2	. . .	. . .	. . .	. . .	. . .	. . .	. . .	83·4
Lehigh,	Coopersburg,	520	. . .	. . .	. . .	59·8	83·0	1	35·0	2	71·5	49·3	22·2	34·0	31	10·0	4	. . .
Lehigh,[1]	Lynnport,	350	. . .	. . .	. . .	59·0	85·0	31	29·0	9	72·2	45·8	26·4	45·0	1	8·0	25	. . .
Luzerne,	Drifton— Drifton Hospital,	1,655	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Luzerne,[1]	Wilkes-Barre,	575	. . .	. . .	. . .	59·0	80·0	31	30·0	6, 9	72·0	46·5	25·5	42·0	31	15·0	26	. . .
Lycoming,[1]	Nisbet,	550	. . .	. . .	. . .	57·0	74·0	5	23·0	1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Mercer,[1]	Greenville— Thiel College,	1,000	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Mifflin,	Lewistown,	500	. . .	. . .	. . .	61·2	83·0	13, 31	31·0	2	72·3	46·6	25·7	48·0	2…	5·5	26	71·9
Montgomery,	Pottstown,	150	. . .	. . .	. . .	62·8	84·0	1	37·0	2, 9	73·1	52·7	20·4	32·0	6…	7·0	4	70·0
Northampton,	Bethlehem,	360	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Perry,	New Bloomfield,	400	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Philadelphia,[1]	Philadelphia— Signal Office,	117	29·990	30·320	29·610	62·7	84·…	. . .	39·0	2	72·1	53·4	18·7	29·0	13	9·0	11	69·0
Potter,	Coudersport,	1,670	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Schuylkill,	Girardville,	1,000	29·959	30·325	29·599	58·7	7…	. . .	31·0	2	68·0	47…	21·0	33·0	9	10·0	4	. . .
Snyder,	Selins Grove,	445	. . .	. . .	. . .	59·8	…0	…4	34·0	3	70·8	…·…	31·7	40·0	2	20·0	8	73·2
Somerset,	Somerset,	2,250	. . .	. . .	. . .	55·7	. . .	4	26·0	2	69·8	44·9	24·9	46·0	2	8·0	28	82·5
Sullivan,	Eagles Mere,	2,060	30·031	30·351	29·709	58·5	07·…	31	26·0	2	58·7	43·7	15·0	27·0	1…	4·0	4	78·0
Tioga,	Wellsboro,	1,327	29·923	30·369	29·405	53·5	80·0	24	26·0	2	64·7	44·6	20·1	34·0	2	4·0	26	64·7
Union,[1]	Lewisburg,	450	. . .	. . .	. . .	59·9	83·0	31	30·0	2	72·3	47·5	24·8	39·0	9	9·0	26	. . .
Warren,	Columbus,	1,410	. . .	. . .	. . .	54·4	81·0	19	24·0	2	65·5	43·3	22·2	42·0	2	4·0	20	67·0
Washington,	Canonsburg,	950	. . .	. . .	. . .	. . .	86·0	. . .	29·0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Wayne,	Dyberry,	1,120	. . .	. . .	. . .	54·0	79·0	24	25·0	9	65·4	42·0	23·4	40·0	9	9·0	26	. . .
Wayne,	Honesdale,	1,000	. . .	. . .	. . .	56·4	76·0	24	29·0	2, 9	64·8	46·0	18·8	37·0	9	7·0	26	65·4
Westmoreland,	Greensburg,	1,175	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Westmoreland,	Ligonier,	1,750	. . .	. . .	. . .	60·4	86·0	24	28·0	2	75·0	47·0	28·0	52·0	13	9·0	6	80·0
Wyoming,[1]	South Eaton	660	. . .	. . .	. . .	56·3	78·0	13	30·0	2, 9	66·6	46·0	20·6	35·…	9	8·0	26	. . .
York,[1]	York,	385	29·943	30·…81	29·588	59·8	83·0	19	34·0	2	72·…	47·6	24·5	39·…	12	12·0	15	80·5

[1] Observations taken at 7 A. M. and 2 P. M. [illegible]

TEMPERATURE.													PRECIPI
MAXIMUM.		MINIMUM.				DAILY RANGE.							
Highest.	Date.	Lowest.	Date.	Mean of Maxima.	Mean of Minima.	Mean.	Greatest.	Date.	Least.	Date.	Relative Humidity.	Dew Point.	Total Inches.
83·0	1	32·0	2	70·6	45·0	25·6	38·0	13	3·0	6	. . .	. . .	8·10
86·0	30	37·0	2	71·4	52·5	18·9	36·0	18	9·0	7	81·6	55·0	5·85
82·0	13	28·0	2	70·2	42·0	28·2	42·0	12	7·0	7	79·9	54·0	8·65
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
80·0	14	35·0	2	71·0	52·2	18·8	36·0	2	10·0	23	55·1	45·0	4·47
83·0	13	30·0	2	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	6·70
84·0	13	29·0	2	72·0	46·0	26·0	44·0	12	6·0	26	81·0	54·0	5·28
85·0	31	33·0	2, 3	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5·05
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
77·0	14, 24	30·0	2	64·0	46·9	17·1	35·0	12	1·0	30	. . .	. . .	7·00
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5·00
80·7	19	31·0	9	70·8	46·9	23·9	37·0	31	12·0	4	76·6	51·0	6·55
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
82·0	13	33·0	2	71·1	47·8	23·3	38·0	18	9·0	26	80·7	52·2	6·90
81·0	13, 29	28·0	2	70·0	44·8	25·2	46·0	3	9·0	14	. . .	. . .	9·61
79·0	1, 14	30·0	9	70·5	46·4	24·1	39·0	9	7·0	4	. . .	. . .	8·11
76·0	29	27·0	2	66·8	47·0	19·8	37·0	3	5·0	26	74·6	48·7	6·77
83·0	13	25·0	2	69·1	44·7	24·4	45·0	12	6·0	4	. . .	. . .	7·02
82·5	1	35·0	2	70·3	51·0	19·3	29·5	1	11·0	25	72·0	57·5	6·42
84·0	1	33·0	9	72·9	49·0	23·9	35·5	9	10·0	4	. . .	. . .	7·85
74·0	13	42·0	2, 3	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	6·89
81·5	1	36·0	9	70·6	51·5	19·1	30·5	9	11·5	27	. . .	. . .	5·90
88·0	30	36·0	1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
80·0	24	29·0	7	65·7	44·9	20·8	35·0	31	11·0	14	78·8	49·5	7·20
80·0	24, 30	28·0	2	67·5	47·8	19·7	38·0	12	2·0	6	. . .	. . .	6·87
80·0	24	29·0	2	69·0	46·0	23·0	38·0	12	6·0	25	. . .	. . .	7·30
78·5	13	33·0	2	68·5	49·0	19·5	. . .	. . .	. . .	. . .	. . .	. . .	7·41
78·5	30	30·0	2	64·6	44·0	20·6	34·0	3	9·0	6	80·4	47·6	7·04
83·0	1, 13	34·0	11, 12	72·9	48·8	24·1	41·0	12	7·0	25	36·0	56·0	5·47
79·0	13	38·0	2	70·0	51·6	18·4	30·0	17	9·0	25	66·8	48·2	6·01
82·0	19	38·5	2, 9	71·9	56·1	15·8	29·5	9	10·0	25	78·0	53·0	5·59
79·0	25	34·0	2	62·0	45·0	17·0	35·0	3	6·0	6	80·0	47·0	6·40
86·0	29	34·0	2	73·3	49·4	23·9	45·0	18	9·0	20	. . .	. . .	8·03
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
82·0	13, 14	30·0	12	72·0	46·1	25·9	41·0	12	10·0	26	83·0	53·4	5·55
80·0	13, 30	34·0	2	70·9	48·9	22·0	36·0	17	4·0	25	78·6	52·5	7·90
86·0	30	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·90
88·0	13	31·0	2	71·5	53·3	18·2	42·0	12	4·0	26	. . .	. . .	6·36
88·0	31	30·0	2	68·9	46·7	22·2	39·0	18	7·0	25	. . .	. . .	6·95
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
78·0	24	32·0	8	67·5	49·3	18·2	36·0	1	6·0	2	69·8	49·6	4·77
80·0	14	34·0	2	71·0	49·8	21·2	33·1	12	6·9	25	66·3	56·2	7·04
85·0	30	26·0	2	72·3	45·1	27·2	46·0	2	13·0	19	. . .	. . .	7·25
82·0	6	32·0	9	71·0	47·4	24·2	37·0	9	9·9	4	79·1	52·1	6·79
85·0	19	42·0	2	. . .	. . .	. . .	. . .	. . .	. . .	. . .	83·4	59·8	. . .
83·0	1	35·0	2	71·5	49·3	22·2	34·0	31	10·0	4	. . .	. . .	7·93
85·0	31	29·0	9	72·2	45·8	26·4	45·0	1	8·0	25	. . .	. . .	5·00
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
89·0	31	30·0	6, 9	72·0	46·5	15·5	42·0	31	15·0	26	. . .	. . .	6·84
74·0	5	23·0	1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	6·20
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
83·0	13, 31	31·0	2	72·3	46·6	25·7	48·0	13	5·5	26	71·9	53·0	6·88
84·0	1	37·0	2, 9	73·1	52·7	20·4	32·0	1	7·0	4	76·0	54·0	7·61
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
84·0	19	39·0	2	72·1	53·4	18·7	29·0	13	9·0	11	69·0	50·0	2·96
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
76·0	31	31·0	2	68·0	47·0	21·0	33·0	9	10·0	4	. . .	. . .	12·41
81·0	24	34·0	3	70·8	39·1	31·7	40·0	2	20·0	8	73·2	43·8	3·56
82·0	4	26·0	2	69·8	44·9	24·9	46·0	2	8·0	28	82·5	50·9	8·90
67·0	31	26·0	2	58·7	41·7	15·0	27·0	12	4·0	4	78·0	45·3	8·97
80·0	24	26·0	2	64·7	44·6	20·1	34·0	2	4·0	26	64·7	38·4	7·80
83·0	31	30·0	2	70·3	47·5	24·8	39·0	9	9·0	26	. . .	. . .	6·40
81·0	29	24·0	2	65·5	43·3	22·2	42·0	2	4·0	20	67·0	42·5	9·15
86·0	. . .	29·0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5·20
76·0	24	25·0	9	65·4	42·0	23·4	40·0	9	9·0	26	. . .	. . .	5·56
76·0	24	29·0	2, 9	64·8	46·0	18·8	37·0	9	7·0	26	63·4	52·0	6·11
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
86·0	24	28·0	2	75·0	47·0	28·0	52·0	13	9·0	6	80·0	54·0	5·79
78·0	13	30·0	2, 9	66·6	46·0	20·6	35·0	9	8·0	26	. . .	. . .	7·47
83·0	19	34·0	2	72·1	47·6	24·5	39·0	12	12·0	15	80·5	52·9	6·05

WEATHER SERVICE FOR MAY, 1890.

Dew Point.	Precipitation. Total Inches.	Precipitation. Number of Days Rainfall.	Number of Days. Clear.	Number of Days. Fair.	Number of Days. Cloudy.	Wind. Prevailing Direction. 7 A. M.	Wind. Prevailing Direction. 2 P. M.	Wind. Prevailing Direction. 9 P. M.	Observers.
. . .	8·10	13	6	7	18	S	S	S	Prof. E. S. Breidenbaugh.
55·0	5·85	20	6	8	17	SW	SW	SW	Oscar D. Stewart, Sgt. Sig. Corps.
54·0	5·65	16	5	13	13	SW	SW	SW	Miss E. A. G. Apple.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	C. M. Dechant, C.E.
45·0	4·47	14	. . .	. . .	. . .	. . .	. . .	. . .	Dr. Charles B. Dudley.
. . .	6·70	13	6	12	13	NW	NW	NW	A. H. Boyle.
54·0	5·85	18	8	9	14	SW	W	W	Prof. J. A. Stewart.
. . .	5·05	16	9	9	13	W	W	W	Miss Cora J. Wilson.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Charles Beecher.
. . .	7·00	15	7	10	14	SW	SW	SW	Geo. W. T. Warburton.
. . .	5·00	10	10	12	8	NW	NW	W	J. C. Hilsman.
51·0	6·55	22	0	10	13	SW	SW	S	J. L. Heacock.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Lewis P. Townsend.
52·2	6·90	23	7	9	15	SE	SE	SE	E. C. Lorentz.
. . .	9·61	14	9	8	14	W	W	W	T. B. Lloyd.
. . .	8·11	16	10	12	9	NW	NW	NW	John J. Boyd.
48·7	6·77	18	4	11	16	W	W	W	Prof. Wm. Frear.
. . .	7·02	15	. . .	. . .	. . .	SW	SW	SW	Geo. H. Dunkle.
57·5	6·42	18	12	13	6	E	S	SE	Jesse C. Green, D.D.S.
. . .	7·85	14	10	11	10	W	S	S	W. T. Gordon.
. . .	6·89	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Benj. P. Kirk.
. . .	5·90	14	8	13	10	W	W	NW	Prof. Wm. F. Wickersham.
. . .	. . .	. . .	6	13	12	W	W	SW	Rev. W. W. Deatrick, A.M.
49·5	7·20	. . .	. . .	. . .	. . .	SW	SW	SW	C. M. Thomas, B.S.
. . .	6·87	19	2	11	18	W	SW	SW	Nathan Moore.
. . .	7·30	17	6	13	12	W	W	W	Prof. John A. Robb.
. . .	7·41	10	. . .	. . .	. . .	. . .	. . .	. . .	Robert M. Graham.
47·6	7·04	17	5	17	9	S	S	S	J. & B. H. Metcalf.
56·0	5·47	16	3	15	13	S	S	S	J. E. Pague.
48·2	6·61	17	6	13	12	E	E	E	Frank Ridgway, Sgt. Sig. Corps.
53·0	5·59	13	3	9	19	N	SW	N	Prof. Susan J. Cunningham.
47·0	6·40	20	5	9	17	W	W	W	Peter Wood, Sgt. Sig. Corps.
. . .	8·03	17	8	17	6	. . .	. . .	. . .	Wm. Hunt.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	R. L. Haslet.
53·4	5·55	17	9	7	15	. . .	. . .	. . .	Miss Mary A. Ricker.
52·5	7·90	16	9	12	10	W	NW	W	Thomas F. Sloan.
. . .	4·90	14	10	9	12	. . .	. . .	. . .	Capt. W. C. Kimber.
. . .	6·36	14	5	12	14	W	W	W	Prof. W. J. Swigart.
. . .	6·95	16	7	10	14	W	W	W	J. E. Rooney.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Prof. S. C. Schmucker.
49·6	4·77	16	3	7	21	S	S	S	C. A. Hinsdell.
56·2	7·04	12	9	12	10	NW	W	W	C. N. Heller.
. . .	7·35	14	8	10	13	W	W	W	Wm. T. Butz.
52·1	6·79	13	5	8	18	W	W	W	Wm. H. Kline.
52·8	. . .	. . .	4	12	15	W	W	W	Geo. W. Bowman, A.M., Ph.D.
. . .	7·93	12	7	15	9	SE	SW	SE	M. H. Boyer.
. . .	5·00	. . .	6	12	13	. . .	. . .	. . .	John C. Wuchter.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	H. D. Miller, M.D.
. . .	6·84	13	11	4	16	NE	. . .	N	A. W. Betterly.
. . .	6·20	11	9	11	11	W	. . .	E	John S. Gibson, P. M.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Prof. S. H. Miller.
53·0	6·88	16	8	13	10	NW	NW	NW	Culbertson & Lantz.
54·0	7·61	10	15	8	8	W	W	W	Charles Moore, D.D.S.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Lerch & Rice.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Frank Mortimer.
50·0	2·96	16	7	13	11	SE	SE	SE	Luther M. Dey, Sgt. Sig. Corps.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	C. L. Peck.
. . .	12·41	16	15	7	9	NW	NW	W	E. C. Wagner.
43·8	3·56	12	10	15	6	SE	SE	SE	J. M. Boyer,
50·9	8·90	14	2	14	15	NW	NW	NW	W. M. Schrock.
45·3	8·97	13	6	12	13	SW	SW	SW	E. S. Chase.
38·4	7·80	20	4	13	14	N	S	N	H. D. Deming.
. . .	6·40	13	1	19	11	SW	SW	SW	F. O. Whitman.
42·5	9·15	20	6	10	15	SW	SW	SW	Wm. Loveland.
. . .	5·20	23	. . .	. . .	. . .	. . .	. . .	. . .	A. L. Runion, M.D.
. . .	5·56	12	5	12	14	NW	NW	NW	Theodore Day.
52·0	6·11	12	. . .	. . .	. . .	. . .	. . .	. . .	John Torrey.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Hilary S. Brunot.
54·0	6·79	20	. . .	. . .	. . .	. . .	. . .	. . .	J. T. Ambrose.
. . .	7·47	15	7	10	14	S	S	S	Benj. M. Hall.
52·9	6·65	11	15	8	8	NW	. . .	SW	Mrs. L. H. Grenewald.

T. F. TOWNSEND, *Sergeant Signal Corps, Assistant.*

Wellsboro.	Harrisburg.	Charlesville.	Lynnport.	Tionesta.	Gettysburg.	Lewistown.	Greensburg.	Tipton.	Coudersport.	Coopersburg.	Hulmeville.	Westtown.	Meadville.	Ligonier.	Scranton.
.12	.04	.01	. .	. .	.42	.08	. .	.20	. .	.12	. .	.28	.19	.26	.20
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
.05	.8 .	. .	. .	. .	. .	. .	. .	.05	. .	. .	. .	. .	.05	. .	. .
.42	.8 .	.06	. .	. .	. .	. .	. .	.05	. .	.91	. .	. .	.56	.12	.24
.40	.38	.66	. .	. .	.47	.42	. .	.09	. .	.89	. .	. .	.60	.61	.20
.63	.26	.02	. .	. .	.43	.42	. .	.05	. .	.91	. .	. .	.56	.12	.24
. .	. .	.41	. .	. .	.55	.44	. .	.55	. .	.47	. .	.70	. .	.37	.43
. .	. .	.11	. .	. .	.20	.03	. .	. .	. .	. .	. .	. .	. .	.06	. .
.02	. .	. .	. .	. .	. .	. .	. .	. .	. .	.17	. .	.50	. .	. .	. .
.70	.04	.03	. .	. .	. .	.09	. .	. .	. .	. .	. .	. .	.22	.09	. .
.34	.02	.04	. .	. .	.40	.06	. .	.05	. .	. .	. .	.05	1.31	.20	.08
.05	. .	. .	. .	. .	. .	.55	. .	.05	. .	.04	. .	. .	. .	.33	.20
.20	.28	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
.36	.34	.56	. .	. .	.40	1.22	. .	.10	. .	. .	. .	. .	.22	.21	.02
. .	.10	.07	. .	. .	.29	.31	. .	.23	. .	2.18	. .	.95	.21	.47	.75
. .	. .	.01	. .	. .	.72	. .	. .	. .	. .	.26	. .	. .	. .	. .	.12
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.83	.04	.01	.01
. .	. .	. .	. .	. .	. .	. .	. .	.10	. .	. .	. .	. .	.26	. .	. .
.16	2.16	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
.94	.93	.87	. .	. .	1.86	.28	. .	.11	. .	. .	. .	. .	.56	.15	.40
. .	. .	.62	. .	. .	.82	.59	. .	.40	. .	.50	. .	.82	.72	.80	1.18
.05	.03	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.05	. .	. .
.14	.20	. .	. .	. .	. .	.04	. .	. .	. .	. .	. .	. .	.01	.05	. .
. .	.04	.77	. .	. .	.37	.68	. .	1.40	. .	. .	. .	. .	1.77	1.52	.01
.08	. .	. .	. .	. .	.01	. .	. .	. .	. .	. .	. .	. .	.04	.13	. .
.04	.82	1.24	. .	. .	.01	.63	. .	.93	. .	. .	. .	. .	.21	1.00	. .
. .	.08	.17	. .	. .	1.15	1.04	. .	.00	. .	2.03	. .	1.76	. .	.01	.47
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.32	. .	. .	. .	. .	.52
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
.10	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	.04	. .	. .	. .	. .	. .	. .	.12	. .	.04	. .	.01	. .	.01	.04
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.39	. .
8.80	6.61	5.65	5.00	. .	8.10	6.88	. .	5.03	. .	7.93	. .	5.90	7.04	6.79	4.77

T. F. T.

Lunar Halos.—Meadville, 29th; Huntingdon, 28th; Lancaster, 24th, 31st; Lewistown, 1st; Somerset, 27th; Dyberry, 5th.

Parhelias.—Le Roy, 8th, 30th; Annville, 30th.

Zodiacal Lights.—Charlesville, 27th; Le Roy, 2d.

Mirage.—Harrisburg, 11th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for May, 1890:

Weather, 83 per cent.
Temperature, 89 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

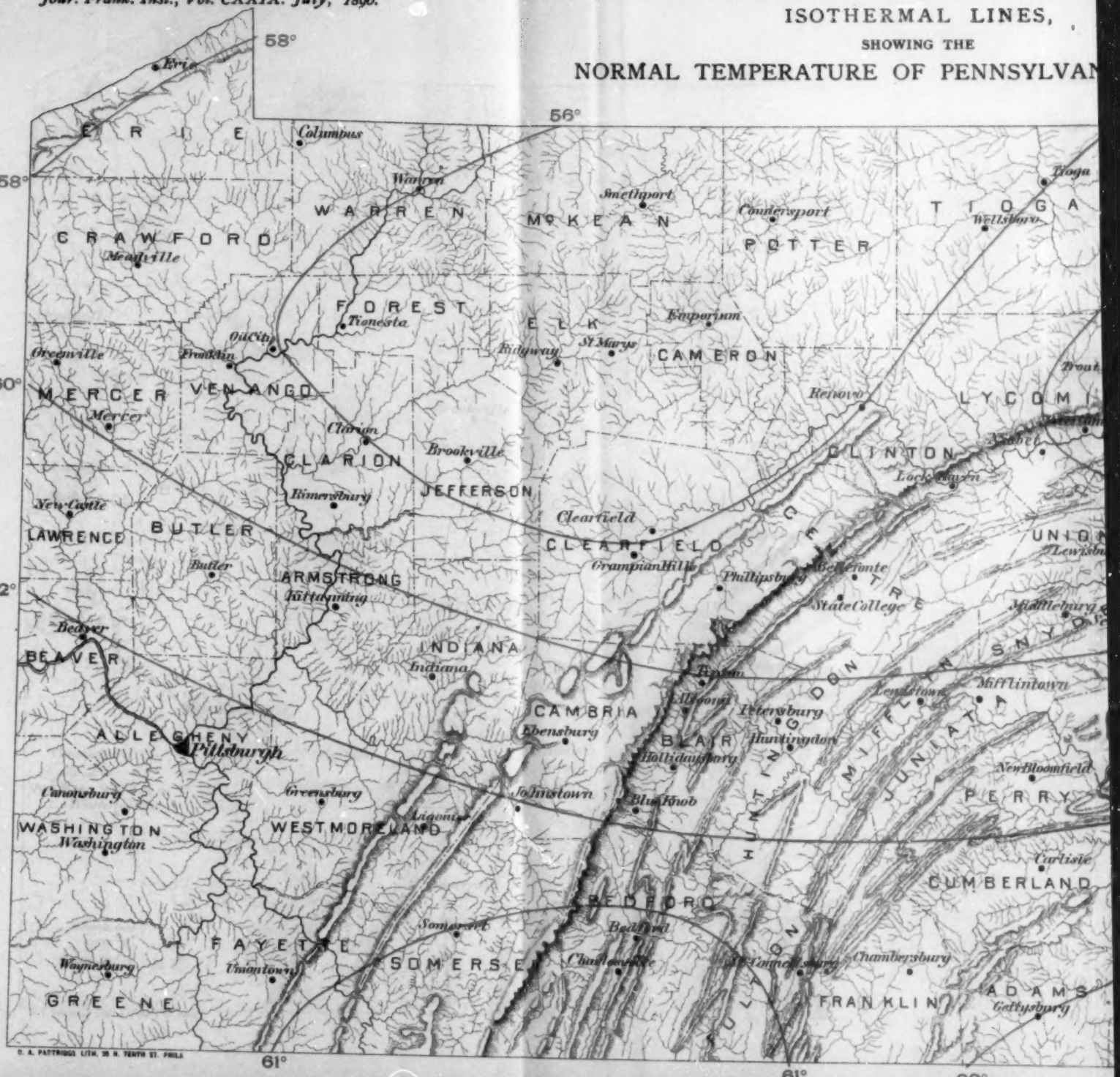
Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Steward M. Dreher,	Stroudsburg.

Displayman.	*Station.*
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
Raftsman's Journal,	Clearfield.
W. S. Ravenscroft,	Hyndman.
R. C. Schmidt & Co.,	Belle Vernon.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
C. A. Hinsdell,	Scranton.
H. J. Fosnot,	Lewistown.
H. M. Kaisinger,	Hartsville.
E. Jennet,	Franklin.
Milton C. Cooper,	Ashbourne.
Geo. W. Bowman,	Annville.
P. S. Weber,	DuBois.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.
Wister Heberton & Co.,	Germantown.
Charles M. Mullen,	Bedford.
E. W. Merrill,	North East.
A. Simon's Sons,	Lock Haven.
Frank Ridgway,	Harrisburg.
G. W. Yost,	Collegeville.
A. C. Tryon,	Spartansburg.

ISOTHERMAL LINES,

SHOWING THE

NORMAL TEMPERATURE OF PENNSYLVAN



C. A. PASTRIDGE LITH. 35 N. TENTH ST. PHILA.

ISOTHERMAL LINES,

SHOWING THE

RMAL TEMPERATURE OF PENNSYLVANIA FOR MAY.

55°
Montrose
SUSQUEHANNA
WAYNE
Dyberry
Honesdale
55°
Tunkhannock
South Easton
WYOMING
LACKAWANNA
Scranton
Bloomsburg
Milford
58°
PIKE
Wilkesbarre
LUZERNE
MONROE
Stroudsburg
60°
Drifton
CARBON
Mauch Chunk
62°
NORTHAMPTON
Easton
Pottsville
Lynnport
Bethlehem
LEHIGH
Allentown
Hamburg
62°
Coopersburg
Quakertown
BUCKS
Doylestown
Reading
MONTGOMERY
60°
Pottstown
Bridgeville
Norristown
63°
CHESTER
West Chester
Swarthmore
Westtown
Media
60°
DELAWARE
Kennett Square
63°

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR JUNE, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, June 30, 1890.

TEMPERATURE.

The mean temperature of 58 stations for June, 1890, was 70°·3, which is about 2° above the normal, and 3°·8 above the corresponding month of 1889.

The mean of the daily maximum and minimum temperatures 81°·8 and 58°·4 give an average daily range of 23°·4, and a monthly mean of 70°·1.

Highest monthly mean, 73°·7 at Uniontown and Huntingdon.

Lowest monthly mean, 64°·2 at Dyberry.

Highest temperature recorded during the month, 97° on the 5th, at Carlisle, and 30th, at Lynnport.

Lowest temperature, 33° on the 14th at Charlesville.

Greatest local monthly range, 31°·3 at Wilkes-Barre.

Least local monthly range, 14°·0 at Erie.

Greatest daily range, 47° at Lock Haven on 25th.

Least daily range, 2° at Wellsboro on 21st.

From January 1, 1890 to June 30, 1890, the excess in temperature at Philadelphia was 71°4, at Erie 42°·1 and at Pittsburgh 68°·5.

BAROMETER.

The mean pressure for the month, 30·00, is about ·03 above the normal. At the U. S. Signal Service Stations, the highest observed was 30·38 at Pittsburgh on the 9th, and the lowest 29·71 at Erie on the 12th.

PRECIPITATION.

The average rainfall 3·42 inches is a deficiency of nearly a half inch. Owing to local thunder-storms the fall was somewhat unevenly distributed, but the difference was not great when compared in large areas.

The largest totals reported in inches were Forks of Neshaminy 5·74, Columbus 5·66, Mauch Chunk 5·25 and Wilkes-Barre 5·07.

The smallest were Philadelphia 1·30 and Selins Grove 1·36.

The heaviest general rains occurred on the 6th, 11th, 12th, 13th, 21st, 22d and 23d.

NOTE.—*This number of the Monthly Weather Review completes the serial maps of "Isothermal Lines Showing the Normal Temperature of Pennsylvania" for each month of the year. They will not be reproduced in future numbers. The "Mean Temperature and Rainfall" maps, however, will be continued as heretofore.*

WIND AND WEATHER.

The prevailing direction of wind was from the west. Thunder-storms were frequent and caused numerous losses to life and property. The weather was seasonable for growth, although the month was characterized by cool nights. A few light frosts occurred in the northern counties.

Average number: Rainy days, 9; clear days, 12; fair days, 11; cloudy days, 7.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Gettysburg, 6th, 11th, 13th; Charlesville, 4th, 5th, 18th, 22d; Hollidaysburg, 3d, 5th, 6th, 10th, 12th, 22d, 28th, 29th; Tipton, 3d, 5th, 11th; Wysox, 4th, 5th, 6th, 11th; Le Roy, 4th, 6th, 11th, 12th, 13th, 24th; Forks of Neshaminy, 4th, 6th, 11th, 12th; Quakertown, 6th, 11th, 12th, 13th; Johnstown, 6th, 11th, 12th, 13th, 17th, 22d, 23d; Emporium, 3d, 5th, 6th, 11th, 12th, 22d, 28th; Mauch Chunk, 5th, 6th, 11th, 23d; State College, 3d, 11th, 12th, 13th, 22d, 28th; Phillipsburg, 5th; West Chester, 6th, 11th, 12th, 24th; Coatesville, 6th, 11th, 12th; Kennett Square, 6th, 11th, 22d, 23d; Westtown, 4th, 11th, 12th, 13th, 23d; Lock Haven, 3d, 6th, 11th, 12th, 22d, 23d, 28th, 29th; Catawissa, 5th, 6th, 11th, 12th; Meadville, 4th, 5th, 6th, 11th, 17th, 22d; Carlisle, 6th, 11th, 12th, 13th, 21st, 24th; Harrisburg, 4th, 6th, 11th, 12th, 22d, 23d, 24th; Uniontown, 5th, 6th, 11th, 13th, 15th, 17th, 29th; Huntingdon, 3d, 5th, 10th, 11th, 12th, 13th, 22d, 23d; Petersburg, 11th, 22d; Lancaster, 6th, 11th, 12th; Myerstown, 6th, 11th, 12th, 21st; Annville, 5th, 6th, 11th, 12th, 13th, 22d, 24th; Coopersburg, 6th, 11th, 12th; Lynnport, 6th, 12th; Wilkes-Barre, 6th, 11th, 12th; Nisbet, 6th, 11th, 13th, 23d; Greenville, 5th, 11th; Lewistown, 3d, 11th, 12th, 16th, 22d, 23d, 28th; Bethlehem, 4th, 5th, 6th, 11th, 12th, 13th, 23d; Philadelphia, 4th, 6th, 12th, 24th; Girardville, 5th, 6th, 12th, 13th, 14th, 23d, 24th; Selins Grove, 4th, 5th, 6th, 10th, 11th, 12th, 22d, 23d, 24th; Somerset, 6th, 12th, 14th, 15th, 21st; Eagles Mere, 4th, 6th, 11th, 12th, 24th; Wellsboro, 3d, 5th, 6th, 11th, 12th, 13th, 17th, 22d; Lewisburg, 11th, 12th, 13th; Columbus, 4th, 5th, 6th, 11th, 17th, 22d; Canonsburg, 12th; Dyberry, 4th, 5th, 6th, 11th, 12th, 13th, 24th; Ligonier, 22d; South Eaton, 4th, 5th, 6th, 11th, 12th, 13th, 24th; York, 6th, 11th, 12th, 13th, 22d, 23d, 24th.

Hail.—Gettysburg, 11th; Meadville, 11th; Lock Haven, 11th; Huntingdon, 22d; Lancaster, 11th; Greenville, 5th, 11th; Girardville, 12th; Somerset, 3d; Eagles Mere, 4th; Wellsboro, 17th; York, 11th.

Frost.—Grampian Hills, 8th; Meadville, 8th; Somerset, 8th; Wellsboro, 1st, 2d, 8th, 9th.

Sleet.—Phillipsburg, 5th.

Aurora.—Quakertown, 8th, 19th.

Coronæ.—Greenville, 26th, 27th, 28th; Lewistown, 27th, 28th, 29th; Somerset, 22d; Eagles Mere, 26th, 30th; Dyberry, 2d, 23d, 27th.

Solar Halos.—Le Roy, 8th, 9th, 20th, 23d; Meadville, 10th, 16th; Dyberry, 2d, 18th.

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Serv

County.	Station.	Elevation above Sea Level (feet).	Barometer Reduced to Sea Level.			Temperature.												Relative Humidity.	Dew Point.	Precipitation	
							Maximum.		Minimum.				Daily Range.								
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.			Total Inches.	Number of Days Rainfall.
Adams,[1]	Gettysburg,	624	. . .	. . .	. . .	70·3	94·0	5	42·0	9	84·8	57·0	27·8	43·0	9	9·0	16	. . .	. . .	3·91	10
Allegheny,[1]	Pittsburgh,	847	30·002	30·375	29·777	73·5	92·0	24	47·0	8	83·3	63·5	20·0	30·0	1	11·0	12	67·4	61·3	3·37	13
Bedford,	Charlesville,	1,300	. . .	. . .	. . .	70·0	91·0	24	33·0	14	81·3	54·8	26·5	46·0	14	7·0	25	77·7	61·5	1·87	6
Berks,[1]	Reading,	304	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Blair,[1]	Altoona,	1,181	. . .	. . .	. . .	74·1	93·0	6	47·0	8, 9	84·1	64·2	19·9	30·0	8	8·0	7	53·9	56·0	2·52	13
Blair,	Blue Knob,	2,500	. . .	. . .	. . .	70·2	90·0	5, 24	44·0	28	. . .	. . .	. . .	28·0	8	9·0	17	. . .	. . .	4·60	11
Blair,	Hollidaysburg,	947	. . .	. . .	. . .	71·0	95·0	24	43·0	8	85·0	56·4	28·6	45·0	9	13·0	16	86·0	66·7	4·30	. . .
Blair,	Tipton,	915	. . .	. . .	. . .	71·3	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1·86	9
Bradford,	Wysox,	718	30·014	30·379	29·796	67·2	90·0	5	40·5	1	80·2	55·3	24·9	40·0	3	9·5	21	81·4	60·2	4·75	11
Bradford,	Le Roy,	1,400	. . .	. . .	. . .	68·1	90·0	24	42·0	8	77·2	59·3	17·9	30·0	9	3·0	21	. . .	. . .	4·37	11
Bucks,	Forks of Neshaminy,	. . .	. . .	. . .	. . .	70·8	87·0	5	58·0	8	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5·74	8
Bucks,	Quakertown,	536	30·006	30·340	29·750	69·3	89·7	5	45·2	9	81·2	56·5	24·7	36·0	2	11·0	21	74·9	60·5	3·13	6
Bucks,	Hulmeville,	120	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Cambria,[1]	Johnstown,	1,184	30·039	30·404	29·813	69·9	88·0	5, 24	41·0	8	81·6	58·2	23·4	35·0	27	12·0	12	81·9	63·1	2·72	12
Cameron,	Emporium (27 days),	1,030	. . .	. . .	. . .	71·7	91·0	24	39·0	8	81·9	54·8	27·1	45·0	2	14·0	21	. . .	. . .	4·85	10
Carbon,[1]	Mauch Chunk,	550	. . .	. . .	. . .	68·8	90·5	5	44·0	9	81·2	56·3	24·9	40·5	9	9·0	17	. . .	. . .	3·85	9
Centre,	State College— Agricultural Experiment Station,	1,191	29·957	30·326	29·696	68·8	88·0	25, 26	43·0	8	79·6	58·5	21·1	36·0	9	5·0	16	73·9	59·6	2·34	11
Centre,	Phillipsburg (24 days),	1,350	. . .	. . .	. . .	65·1	92·0	24	37·0	8	81·4	54·6	26·8	46·0	2	7·0	16	. . .	. . .	2·72	. . .
Chester,	West Chester,	455	29·996	30·353	29·752	71·9	89·5	5, 25	51·0	8	80·9	62·1	18·8	27·0	1	11·5	16	69·0	61·0	2·42	9
Chester,	Coatesville,	380	. . .	. . .	. . .	71·5	94·0	25	48·0	1	83·2	56·8	26·4	42·0	30	13·0	16	. . .	. . .	3·07	5
Chester,[1]	Kennett Square,	275	. . .	. . .	. . .	70·5	84·0	25	57·0	8	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2·59	9
Chester,	Westtown,	350	30·010	30·348	29·783	71·6	89·2	25	50·0	9	80·6	61·5	19·1	30·5	9	6·0	21	. . .	. . .	2·83	7
Clarion,	Rimersburg,	1,500	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Clarion,	Clarion— State Normal School,	1,530	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Clearfield,	Grampian Hills,	1,450	. . .	. . .	. . .	70·0	90·0	5, 24	42·0	8	81·5	61·7	19·8	36·0	9	6·0	6	. . .	. . .	2·74	10
Clinton,	Lock Haven,	560	. . .	. . .	. . .	70·7	92·0	5	42·0	8	82·9	56·3	26·6	47·0	25	4·0	6	. . .	. . .	3·61	12
Columbia,	Catawissa,	491	. . .	. . .	. . .	71·0	90·0	5	50·0	11	82·0	59·5	22·5	. . .	. . .	. . .	. . .	. . .	. . .	2·72	10
Crawford,	Meadville,	1,300	29·980	30·380	29·700	67·5	86·0	30	50·0	8	77·4	. . .	. . .	. . .	. . .	. . .	. . .	82·0	62·5	1·92	6
Cumberland,	Carlisle,	480	. . .	. . .	. . .	72·2	97·0	5	44·5	8	86·3	60·1	26·2	39·0	2	10·0	19	33·5	66·3	2·90	8
Dauphin,[1]	Harrisburg,	361	30·004	30·359	29·768	72·1	92·0	26	51·0	8	82·3	62·6	19·7	32·0	9	4·0	16	63·3	62·6	2·97	10
Delaware,	Swarthmore— Swarthmore College,	190	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Erie,[1]	Erie,	681	29·970	30·370	29·710	68·0	85·0	3	46·0	8	75·0	61·0	14·0	22·0	3	5·0	12	76·0	60·0	4·23	9
Fayette,	Uniontown,	1,000	30·030	30·297	29·427	73·7	91·0	24	43·0	8	83·7	62·6	21·1	36·0	2	4·0	21	. . .	. . .	4·33	10
Forrest,	Tionesta,	1,057	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Franklin,[1]	Chambersburg— Wilson Female College,	618	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Fulton,	McConnellsburg,	875	. . .	. . .	. . .	70·2	91·0	24	42·0	8	83·7	58·5	25·2	40·0	9	8·0	16	77·4	62·0	4·87	7
Greene,	Waynesburg,	750	. . .	. . .	. . .	70·7	93·0	24	. . .	. . .	81·9	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3·85	11
Huntingdon,[1]	Huntingdon— The Normal College,	650	. . .	. . .	. . .	73·7	91·0	5	39·0	8	84·3	63·1	21·2	42·5	27	7·0	29	. . .	. . .	4·18	8
Huntingdon,	Petersburg,	700	. . .	. . .	. . .	69·9	95·0	24	42·0	8	84·6	58·5	26·1	46·0	9	8·0	16	. . .	. . .	3·27	11
Indiana,	Indiana— State Normal School,	1,350	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Lackawanna,[1]	Scranton,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Lancaster,	Lancaster (17 days),	411	. . .	. . .	. . .	70·4	91·5	5	45·4	8	81·5	58·2	23·3	. . .	. . .	. . .	. . .	. . .	. . .	2·20	. . .
Lawrence,	New Castle,	932	. . .	. . .	. . .	73·4	91·0	24, 30	38·0	8	83·3	55·5	27·8	45·0	2	12·0	12	. . .	. . .	2·65	7
Lebanon,	Myerstown,	474	29·972	30·292	29·744	70·5	94·5	23	47·0	1	84·1	57·9	26·2	43·0	28	9·5	21	78·0	60·0	2·80	6
Lebanon,	Annville— Lebanon Valley College,	339	. . .	. . .	. . .	75·9	94·0	5	56·0	8	. . .	. . .	. . .	20·0	8	4·0	21	81·3	70·5	. . .	. . .
Lehigh,	Coopersburg,	520	. . .	. . .	. . .	70·0	90·0	5	50·0	1	80·6	60·1	20·5	34·0	1	7·0	21	. . .	. . .	3·14	7
Lehigh,[1]	Lynnport,	350	. . .	. . .	. . .	70·8	97·0	30	45·0	1, 8	84·5	57·0	27·5	44·0	1	4·0	7	. . .	. . .	4·40	3
Luzerne,	Drifton— Drifton Hospital,	1,655	. . .	. . .	. . .	65·3	88·0	5	45·0	8	77·6	57·0	20·6	32·0	9	5·0	21	. . .	. . .	3·64	7
Luzerne,[1]	Wilkes-Barre,	575	. . .	. . .	. . .	71·0	91·0	5, 24	42·0	1	86·8	55·5	31·3	42·0	1	10·0	17	. . .	. . .	5·07	9
Lycoming,[1]	Nisbet,	550	. . .	. . .	. . .	69·8	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3·50	7
Mercer,[1]	Greenville— Thiel College,	1,000	29·942	30·356	29·667	67·8	89·0	30	43·0	9	81·1	56·2	24·9	36·2	9	6·7	12	84·1	62·7	3·44	7
Mifflin,	Lewistown,	500	. . .	. . .	. . .	70·1	93·0	5	45·0	8	86·4	54·6	31·8	43·5	1	9·5	21	66·6	64·6	3·76	12
Montgomery,	Pottstown,	150	. . .	. . .	. . .	72·2	94·0	5	51·0	9	84·0	61·0	23·0	34·0	30	6·0	21	79·0	63·0	2·11	4
Northampton,	Bethlehem,	360	. . .	. . .	. . .	73·1	94·0	30	50·0	1, 2	82·0	60·4	21·6	37·0	1	8·0	17	63·8	62·2	3·10	7
Perry,	New Bloomfield,	400	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Philadelphia,[1]	Philadelphia— Signal Office,	117	30·001	30·362	29·800	73·4	92·0	25	55·0	8	83·0	64·2	18·8	25·0	6	10·0	21	64·0	58·0	1·30	6
Potter,	Coudersport,	1,670	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Schuylkill,	Girardville,	1,000	29·968	30·292	29·743	70·0	89·0	6	47·0	1, 9	80·0	59·0	21·0	33·0	9	8·0	21	. . .	. . .	4·56	8
Snyder,	Selins Grove,	445	. . .	. . .	. . .	73·5	92·0	5	. . .	. . .	83·4	63·5	19·9	. . .	. . .	. . .	. . .	73·7	63·2	1·36	4
Somerset,	Somerset,	2,250	. . .	. . .	. . .	68·1	86·0	24, 25	45·0	20	79·2	58·4	20·8	34·0	9	7·0	7	80·0	63·1	4·93	9
Sullivan,	Eagles Mere,	2,000	30·041	30·439	29·870	65·4	80·0	24, 30	42·0	9	71·7	57·1	14·6	32·0	9	9·0	22	77·5	57·9	3·74	7
Tioga,	Wellsboro,	1,327	29·957	30·309	29·683	64·5	90·0	5	40·0	8	80·4	56·2	24·2	34·0	1	2·0	21	72·0	58·0	5·14	12
Union,[1]	Lewisburg,	450	. . .	. . .	. . .	71·9	94·0	30	45·0	8	85·3	58·5	26·8	39·0	9	12·0	21	. . .	. . .	2·80	6
Warren,	Columbus,	1,410	. . .	. . .	. . .	67·5	90·0	30	34·0	8	79·8	55·4	24·4	45·0	2	4·0	12	68·7	56·4	5·66	13
Washington,	Canonsburg (29 days),	950	30·002	30·336	29·078	70·7	91·0	24	42·0	8	84·1	58·8	25·3	34·0	28	15·0	12	79·7	64·7	1·82	9
Wayne,	Dyberry,	1,100	. . .	. . .	. . .	64·2	86·0	4	38·0	1	76·5	51·8	24·7	39·0	1	10·0	21	. . .	. . .	4·24	10
Wayne,	Honesdale,	1,000	. . .	. . .	. . .	66·2	87·0	4	44·0	1, 2	77·1	55·3	21·8	35·0	1	9·0	21	66·0	61·5	4·14	10
Westmoreland,	Greensburg,	1,175	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Westmoreland,	Ligonier,	1,750	. . .	. . .	. . .	72·1	91·0	30	39·0	8	83·8	56·2	27·6	44·0	2	12·0	12	75·0	64·0	1·94	6
Wyoming,[1]	South Eaton	660	. . .	. . .	. . .	67·5	87·0	5	44·0	1	77·4	57·6	19·8	32·0	3	6·0	21	. . .	. . .	2·81	10
York,[1]	York,	385	29·966	30·297	29·745	71·2	94·0	5	46·0	1	82·6	58·5	24·1	40·0	3	8·0	16	75·0	62·2	3·29	10

Temperature.											Relative Humidity.	Dew Point.	Precipitation.		
imum.	Minimum.		Mean of Maximum.	Mean of Minimum.	Daily Range.										
Date.	Lowest.	Date.			Mean.	Greatest.	Date.	Least.	Date.				Total Inches.	Number of Days Rainfall.	
5	42·0	9	84·8	57·0	27·8	43·0	9	9·0	16	. . .	. . .	. . .	3·91	10	1
24	47·0	28	83·5	63·5	20·0	30·0	1	11·0	12	67·4	61·3	61·3	3·37	13	
24	33·0	14	81·3	54·8	26·5	46·0	14	7·0	25	77·7	61·5	61·5	1·87	6	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
6	47·0	8, 9	84·1	64·2	19·9	30·0	8	8·0	7	53·9	56·0	56·0	2·52	13	. .
5, 24	44·0	28	. . .	. . .	. . .	28·0	8	9·0	17	. . .	. . .	. . .	4·60	11	1
24	42·0	8	85·0	56·4	28·6	45·0	9	13·0	16	86·0	66·7	66·7	4·30	. . .	1
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1·86	9	. .
5	40·5	1	80·2	55·3	24·9	40·0	3	9·5	21	81·4	60·2	60·2	4·75	11	
24	42·0	8	77·2	59·3	17·9	30·0	9	3·0	21	. . .	. . .	. . .	4·37	11	
5	58·0	8	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5·74	8	1
5	45·2	9	81·2	56·5	24·7	36·0	2	11·0	21	74·9	60·5	60·5	3·13	6	1
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
5, 24	42·0	8	81·6	58·2	23·4	35·0	27	12·0	12	81·2	63·1	63·1	2·72	12	
24	39·0	8	81·9	54·8	27·1	45·0	2	14·0	21	. . .	. . .	. . .	4·85	10	1
5	44·0	9	81·2	56·3	24·9	40·5	9	9·0	17	. . .	. . .	. . .	5·25	9	1
25, 26	43·0	8	79·6	58·5	21·1	36·0	9	5·0	16	73·9	59·6	59·6	2·34	11	
24	37·0	8	81·4	54·6	26·8	46·0	2	7·0	16	. . .	. . .	. . .	2·72	. . .	
5, 25	51·0	8	80·9	62·1	18·8	27·0	1	11·5	16	69·0	61·0	61·0	2·42	9	2
25	48·0	1	83·2	56·8	26·4	42·0	30	13·0	16	. . .	. . .	. . .	3·07	5	1
25	57·0	8	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2·39	9	1
25	50·0	9	80·6	61·5	19·1	30·5	9	6·0	21	. . .	. . .	. . .	2·83	7	1
. . .	. . .	. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
5, 24	40·0	8	81·5	61·7	19·8	36·0	9	6·0	6	. . .	. . .	. . .	2·74	10	1
5	42·0	8	82·9	56·3	26 6	47·0	25	4·0	6	. . .	. . .	. . .	3·61	12	1
5	50·0	11	82·0	59·5	22·5	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2·72	10	. .
30	50·0	8	77·4	. . .	. . .	. . .	. . .	. . .	. . .	82·0	62·5	62·5	1·92	6	1
5	44·5	8	86·3	60·1	26·2	39·0	2	10·0	19	33·5	66·9	66·9	2·90	8	
26	51·0	8	82·3	62·6	19·7	32·0	9	4·0	16	63·3	62·6	62·6	2·97	10	1
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
3	46·0	8	75·0	61·0	14·0	22·0	3	5·0	12	76·0	60·0	60·0	4·23	9	
24	43·0	8	83·7	62·6	21·1	36·0	2	4·0	21	. . .	. . .	. . .	4·33	10	1
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
24	42·0	8	83·7	58·5	25·2	40·0	9	8·0	16	77·4	62·0	62·0	4·87	7	1
24	. . .	. . .	81·9	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3·85	11	1
5	39·0	8	84·3	63·1	21·2	42·5	27	7·0	29	. . .	. . .	. . .	4·18	8	1
24	42·0	8	84·6	58·5	26·1	46·0	9	8·0	16	. . .	. . .	. . .	3·27	11	1
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
5	46·4	8	81·5	58·2	23·3	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2·20	. . .	
24, 30	38·0	8	83·3	55·5	27·8	45·0	2	12·0	12	. . .	. . .	. . .	2·65	7	1
23	47·0	1	84·1	57·9	26·2	43·0	28	9·5	21	78·0	60·0	60·0	2·80	6	. .
5	56·0	8	. . .	. . .	. . .	30·0	8	4·0	21	81·3	70·5	. . .	. . .	. . .	
5	50·0	1	80·6	60·1	20·5	34·0	1	7·0	21	. . .	. . .	. . .	3·14	7	1
30	45·0	1, 8	84·5	57·0	27·5	44·0	1	4·0	7	. . .	. . .	. . .	4·40	3	1
5	45·0	8	77·6	57·0	20·6	32·0	9	5·0	21	. . .	. . .	. . .	3·64	7	. .
5, 24	42·0	1	86·8	55·5	31·3	42·0	1	10·0	17	. . .	. . .	. . .	5·07	9	1
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3·50	7	1
30	43·0	9	82·1	56·2	24·9	36·2	9	6·7	12	85·1	62·7	62·7	3·44	7	1
5	45·0	8	86·4	54·6	31·8	43·5	1	9·5	21	66·6	64·6	64·6	3·76	12	1
5	51·0	9	84·0	61·0	23·0	34·0	30	6·0	21	79·0	63·0	63·0	2·11	4	2
30	50·0	1, 2	82·0	60·4	21·6	33·0	1	8·0	17	69·8	62·2	62·2	3·10	7	2
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
25	55·0	8	93·0	64·2	28·8	25·0	6	10·0	21	64·0	58·0	58·0	1·30	6	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
6	47·0	1, 9	80·0	59·0	21·0	33·0	9	8·0	21	. . .	. . .	. . .	4·56	8	1
5	. . .	. . .	83·4	63·5	19·9	. . .	. . .	. . .	. . .	73·7	63·2	63·2	1·36	4	1
24, 25	45·0	30	79·2	58·4	20·8	34·0	9	7·0	7	80·0	63·1	63·1	4·93	9	
24, 30	42·0	9	71·7	57·1	14·6	32·0	9	9·0	22	77·5	57·9	57·9	3·72	7	
5	40·0	8	80·4	56·2	24·2	34·0	1	2·0	21	72·0	58·0	58·0	5·14	12	
30	45·0	8	85·3	58·5	26·8	39·0	9	12·0	21	. . .	. . .	. . .	2·80	6	
30	34·0	8	79·8	55·4	24·4	45·0	2	4·0	12	68·7	56·4	56·4	5·66	13	
24	42·0	8	84·1	58·8	25·3	34·0	18	15·0	12	79·7	64·7	64·7	1·82	9	1
4	38·0	1	76·5	51·8	24·7	39·0	1	10·0	21	. . .	. . .	. . .	4·24	10	
4	44·0	1, 2	77·1	55·3	21·8	35·0	1	9·0	21	66·0	61·5	61·5	4·14	10	. .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
30	39·0	8	83·8	56·2	27·6	44·0	2	12·0	12	75·0	64·0	64·0	1·94	6	1
5	44·0	1	77·4	57·6	19·8	32·0	3	6·0	21	. . .	. . .	. . .	2·81	10	1
5	46·0	1	82·6	58·5	24·1	40·0	3	8·0	16	75·0	61·2	61·2	3·29	10	1

CIPITATION.	NUMBER OF DAYS.			WIND.			OBSERVERS.
				PREVAILING DIRECTION.			
Number of Days Rainfall.	Clear.	Fair.	Cloudy.	7 A. M.	2 P. M.	9 P. M.	
10	14	8	8	S	S	S	Prof. E. S. Breidenbaugh.
13	6	20	4	SW	SW	SW	Oscar D. Stewart, Sgt. Sig. Corps.
6	4	18	8	W	NW	SW	Miss E. A. G. Apple.
...	...	...	...	...	...	...	C. M. Dechant, C.E.
13	...	...	...	...	...	...	Dr. Charles B. Dudley.
11	13	10	7	NW	NW	NW	A. H. Boyle.
...	12	9	9	W	W	W	Prof. J. A. Stewart.
9	...	...	...	W	W	W	Miss Cora J. Wilson.
11	6	10	14	SE	SE	SE	Charles Beecher.
11	6	14	10	SW	SW	SW	Geo. W. T. Warburton.
8	15	6	9	W	W	W	J. C. Hilsman.
6	11	10	9	NW	SW	SE	J. L. Heacock.
...	...	...	...	...	...	...	Lewis P. Townsend.
12	5	18	7	SE	SE	SE	E. C. Lorentz.
10	10	12	5	W	W	W	T. B. Lloyd.
9	14	11	5	NW	NW	NW	John J. Boyd.
11	7	15	8	W	W	W	Prof. Wm. Frear.
...	4	13	7	SW	SW	SW	Geo. H. Dunkle.
9	20	5	5	NW	NW	SE	Jesse C. Green, D.D.S.
5	17	6	7	W	S	S	W. T. Gordon.
9	12	12	6	N	...	S	Benj. P. Kirk.
7	15	8	7	W	W	W	Prof. Wm. F. Wickersham.
...	...	...	...	...	...	...	Rev. W. W. Deatrick, A.M.
...	...	...	...	...	...	...	C. M. Thomas, B.S.
10	11	10	9	SW	SW	SW	Nathan Moore.
12	14	12	4	W	W	W	Prof. John A. Robb.
10	...	...	...	...	...	...	Robert M. Graham.
6	12	16	2	SE	S	S	J. & B. H. Metcalf.
8	7	15	8	W	S	S	J. E. Pague.
10	10	11	9	W	W	W	Frank Ridgway. Sgt. Sig. Corps.
...	...	...	...	...	...	...	Prof. Susan J. Cunningham.
9	8	8	14	S	W	S	Peter Wood, Sgt. Sig. Corps.
10	15	12	3	SW	SW	SW	Wm. Hunt.
...	...	...	...	...	...	...	R. L. Haslet.
...	...	...	...	...	...	...	Miss Mary A. Ricker.
7	15	11	4	...	...	...	Thomas F. Sloan.
11	15	9	6	...	...	...	Capt. W. C. Kimber.
8	13	3	14	W	W	W	Prof. W. J. Swigart.
11	16	10	4	W	W	W	J. E. Rooney.
...	...	...	...	...	...	...	Prof. S C. Schmucker.
...	...	...	...	...	...	...	C. A. Hinsdell.
...	8	6	3	SE	W	W	C. N. Heller.
7	13	15	2	S	S	S	Wm. T. Butz.
6	...	...	...	W	W	W	Wm. H. Kline.
...	8	19	3	W	W	W	Geo. W. Bowman, A.M., Ph.D.
7	11	11	8	E	SE	E	M. H. Boye.
3	15	11	4	...	...	...	John C. Wuchter.
7	...	...	...	...	...	...	H. D. Miller, M.D.
9	18	1	11	NE	NE	NE	A. W Betterly.
7	16	7	7	W	W	W	John S. Gibson, P. M.
7	10	10	10	N	N	N	Prof. S. H. Miller.
12	12	13	5	NW	NW	NW	Culbertson & Lantz.
4	21	6	3	W	W	W	Charles Moore, D.D.S.
7	20	3	7	NW	S	W	Lerch & Rice.
...	...	...	...	...	...	...	Frank Mortimer.
6	9	10	11	NW	NW	NW	Luther M. Dey, Sgt. Sig. Corps.
...	...	...	...	...	...	...	C. L. Peck.
8	19	10	1	W	W	NW	E. C Wagner.
4	19	6	5	SW	SW	SW	J. M. Boyer,
9	8	13	9	SW	SW	SW	W. M. Schrock.
7	9	10	11	SW	SW	SW	E. S. Chase.
12	7	11	12	N	N	S	H. D. Deming.
6	8	17	5	SW	SW	SW	F. O. Whitman.
13	9	13	8	SW	SW	SW	Wm. Loveland.
9	17	10	2	SW	SE	W	A. L. Runion, M.D.
10	8	13	9	NW	NW	NW	Theodore Day.
10	...	...	...	...	...	...	John Torrey.
...	...	...	...	...	...	...	Hilary S. Brunot
6	17	12	1	...	...	...	J. T. Ambrose.
10	12	13	5	S	S	S	Benj. M. Hall.
10	18	10	2	NW	NW	NW	Mrs. L. H. Grenewald.

New Bloomfield.	Wellsboro.	Harrisburg.	Selins Grove.	Lewistown.	Greensburg.	Tipton.	Coudersport.	Coopersburg.	Hulmeville.	Westtown.	Meadville.	Ligonier.	Scranton.
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
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. .	2·60	·24	·25	·37	. .	·03	. .	·47	. .	·11	·49	·56	. .
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. .	·20	1·88	·24	·85	. .	·25	. .	1·35	. .	·52	·34	·30	. .
. .	·36	·02	. .	. .	. .	·20	. .	. .	. .	. .	. .	. .	. .
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. .	·26	·28	·83	·35	. .	·25	. .	·71	. .	. .	·58	·17	. .
. .	·05	·04	. .	·80	. .	·24	. .	·02	. .	. .	·03	·69	. .
. .	·08	·17	·73	·13	. .	·60	. .	. .	. .	·45	. .	. .	. .
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. .	5·14	2·97	1·[illegible]	3·76	. .	1·86	. .	3·14	. .	2·83	1·92	1·94	. .

T. F. T.

Lunar Halos.—State College, 26th; Meadville, 29th; Lock Haven, 27th, 30th; Greenville, 29th; Girardville, 29th; Somerset, 21st.

Meteors.—Lewistown, 24th.

Zodiacal Lights.—Charlesville, 13th, 14th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for June, 1890:

Weather, 86 per cent.
Temperature, 92 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

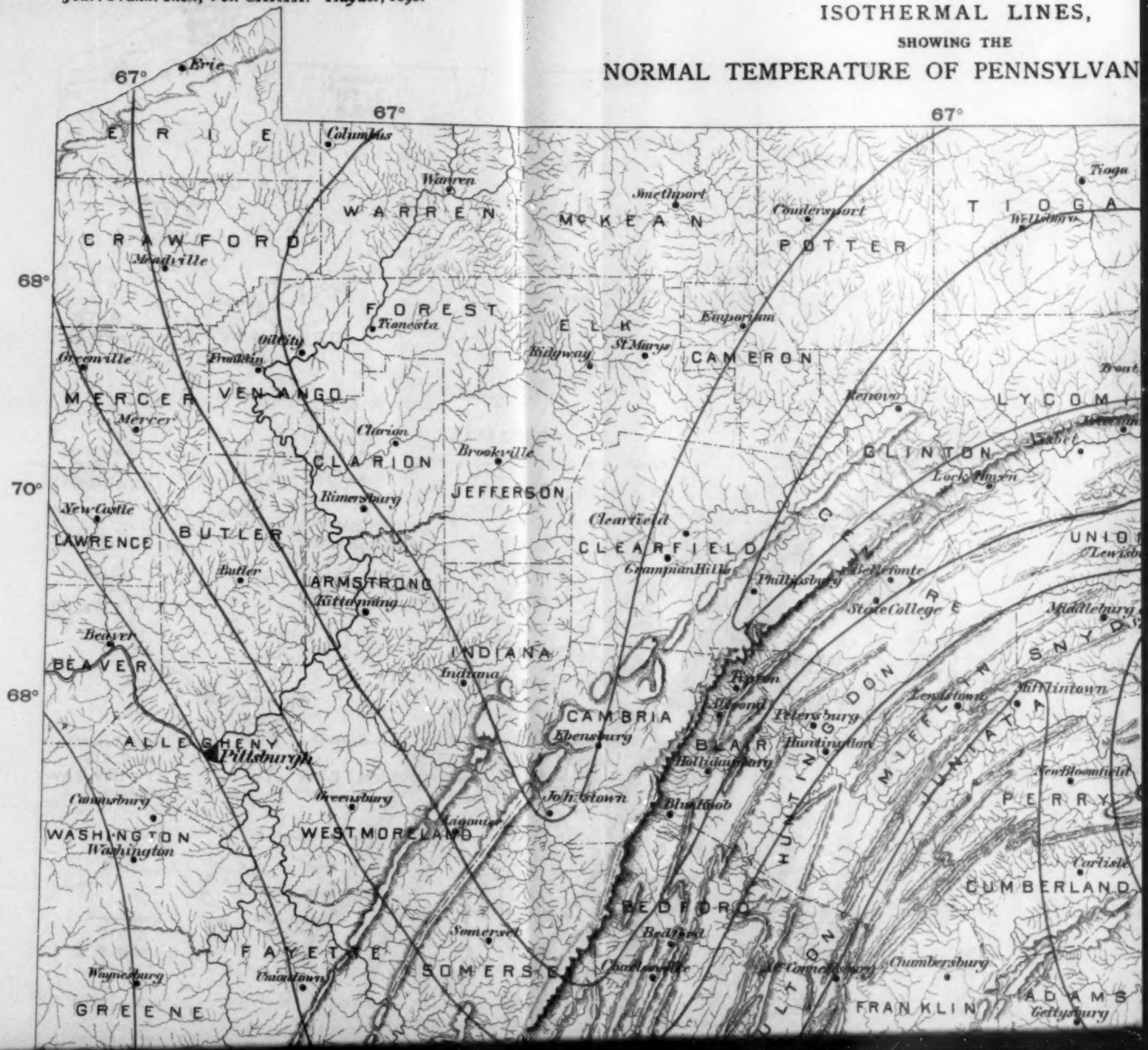
Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Steward M. Dreher,	Stroudsburg.

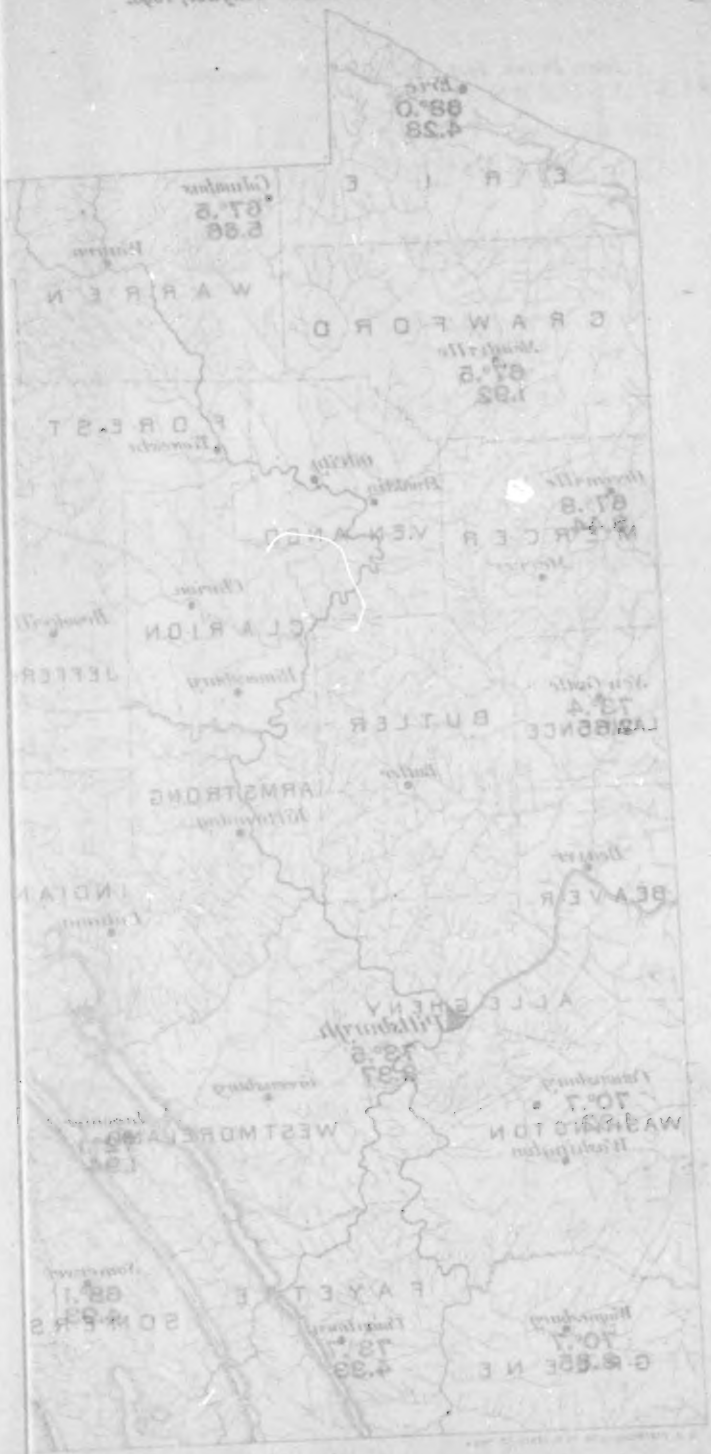
Displayman.	*Station.*
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
Raftsman's Journal,	Clearfield.
W. S. Ravenscroft,	Hyndman.
R. C. Schmidt & Co.,	Belle Vernon.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. Jan es,	Ashland.
Miller & Ai'ison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
C. A. Hinsdell,	Scranton.
H. J. Fosnot,	Lewistown.
H. M. Kaisinger,	Hartsville.
E. Jennet,	Franklin.
Milton C. Cooper,	Ashbourne.
Geo. W. Bowman,	Annville.
P. S. Weber,	DuBois.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.
Wister Heberton & Co.,	Germantown.
Charles M. Mullen,	Bedford.
E. W. Merrill,	North East.
A. Simon's Sons,	Lock Haven.
Frank Ridgway,	Harrisburg.
G. W. Yost,	Collegeville.
A. C. Tryon,	Spartansburg.

ISOTHERMAL LINES,

SHOWING THE

NORMAL TEMPERATURE OF PENNSYLVAN





PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR JULY, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, July 31, 1890.

TEMPERATURE.

The mean temperature of 59 stations for July, 1890, was 70°·8, which is about 1°·5 below the normal, and 1° 4 below the corresponding month of 1889.

The mean of the daily maximum and minimum temperatures 82°·3 and 59°·1 give an average daily range of 23°·2, and a monthly mean of 70°·7.

Highest monthly mean, 75°·1 at Rimersburg.

Lowest monthly mean, 64°·8 at Dyberry.

Highest temperature recorded during the month, 101° on the 8th, at Carlisle and York.

Lowest temperature, 33° on the 6th at Huntingdon.

Greatest local monthly range, 33°·0 at Huntingdon.

Least local monthly range, 14°·9 at Rimersburg.

Greatest daily range, 56° at Huntingdon on 7th.

Least daily range, 3° at Selins Grove on 2d, and Ligonier on 9th.

From January 1, 1890, to July 31, 1890, the excess in temperature at Philadelphia was 666°, at Erie 382° and at Pittsburgh 682°.

BAROMETER.

The mean pressure for the month, 30·03, is about ·07 above the normal. At the U. S. Signal Service Stations, the highest observed was 30·31 at Erie on the 21st, and the lowest 29·716 at Philadelphia on the 3d.

PRECIPITATION.

The average rainfall 3·52 inches for the month, is a deficiency of over a half inch. The distribution was unequally divided, and in some sections growing crops suffered from drouth.

The largest monthly totals in inches were Lynnport, 6·40; Girardville 6·36 and West Chester, 6·27.

The least were Phillipsburg, 0·74 and Erie, 0·76.

WIND AND WEATHER.

The prevailing direction of wind was from the west. The month was characterized by extremes of heat and cold. Several stations reported light frosts on the 21st. The weather was favorable for the harvesting of grass and grain, and unusually large crops of hay were secured.

Average number: Rainy days, 8; clear days, 13; fair days, 11; cloudy days, 7.

Correction.—From January 1, 1890, to June 30, 1890, the excess in temperature at Philadelphia was 714°, at Erie 421° and at Pittsburgh 685°.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Blue Knob, 1st, 4th, 8th, 13th, 15th, 17th, 25th, 27th, 29th; Hollidaysburg, 4th, 15th, 17th, 26th; Wysox, 1st, 2d, 17th, 31st; Le Roy, 2d, 15th, 17th; Quakertown, 17th, 18th; Johnstown, 4th, 25th, 29th; Emporium, 8th, 15th, 17th, 25th, 29th; State College, 2d, 9th, 15th, 17th, 29th; Phillipsburg, 8th, 15th, 17th; West Chester, 3d, 4th, 15th, 17th; Coatesville, 15th, 17th; Kennett Square, 4th, 15th, 17th; Rimersburg, 1st, 2d, 25th, 29th; Lock Haven, 3d, 4th, 9th, 17th, 24th, 27th, 30th; Catawissa, 8th, 15th, 17th, 26th; Meadville, 1st, 2d, 4th, 8th, 17th, 24th, 25th, 28th, 29th, 31st; Carlisle, 2d, 3d; Harrisburg, 3d, 17th; Swarthmore, 3d, 15th, 17th; Erie, 8th, 24th, 25th, 28th, 31st; Uniontown, 1st, 15th; Huntingdon, 2d, 16th, 17th, 27th; Petersburg, 15th, 17th; Indiana, 15th, 25th; Myerstown, 15th, 17th, 28th; Annville, 3d, 15th, 17th; Coopersburg, 17th; Drifton, 15th, 17th; Wilkes-Barre, 15th; Nisbet, 4th, 9th, 15th, 16th, 17th, 29th; Lewistown, 2d, 15th, 17th; Pottstown, 17th; Philadelphia, 3d, 4th, 13th, 17th; Girardville, 2d, 3d, 9th, 17th; Selins Grove, 2d, 3d, 15th, 17th, 29th; Somerset, 15th, 25th; Eagles Mere, 8th, 15th, 17th; Wellsboro, 2d, 8th, 15th, 17th, 25th, 29th; Lewisburg, 2d, 3d, 15th, 17th; Columbus, 8th, 15th, 24th, 31st; Canonsburg, 4th, 15th; Dyberry, 3d, 15th, 17th, 26th; South Eaton, 3d, 8th, 15th, 17th; York, 2d, 3d, 15th, 16th, 18th, 26th.

Hail.—Johnstown, 25th; Catawissa, 17th; Swarthmore, 17th; Uniontown, 15th; Philadelphia, 17th; Girardville, 17th; Selins Grove, 8th, 15th.

Frost.—Blue Knob, 6th, 10th, 21st; Quakertown, 21st, 22d; Emporium, 21st; Phillipsburg, 13th; Grampian Hills, 20th, 21st; Catawissa, 21st; Somerset, 6th, 10th, 20th, 21st; Wellsboro, 10th, 21st, 22d; Lewisburg, 21st; Columbus, 21st; Dyberry, 21st; Honesdale, 21st.

Aurora.—Quakertown, 7th, 9th, 18th.

Coronæ.—Blue Knob, 29th; Annville, 27th.

Solar Halos.—Le Roy, 23d, 27th, 28th; Meadville, 19th, 28th; Wilkes-Barre, 28th; Eagles Mere, 27th, 28th; Dyberry, 28th.

Lunar Halos.—Annville, 27th; Selins Grove, 19th.

Meteors.—Quakertown, 7th; Greenville, 19th; Canonsburg, 21st.

Parhelias.—Le Roy, 17th; Annville, 27th.

Zodiacal Lights.—Charlesville, 4th, 5th, 7th, 9th, 10th.

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather

County.	Station.	Elevation above Sea Level (feet).	Barometer Reduced to Sea Level.			Temperature.												Relative Humidity.	Dew Point.	Prec
							Maximum.		Minimum.				Daily Range.							
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.			Total Inches.
Adams,[1]	Gettysburg,	624	. . .	. . .	. . .	73·3	100·0	8	41·0	21, 22	86·3	59·5	27·0	43·0	22	9·0	24	. . .	. . .	2·78
Allegheny,[1]	Pittsburgh,	847	30·024	30·290	29·732	74·0	94·0	8	53·0	10	84·1	63·9	20·2	31·0	6	9·0	23	62·3	59·0	2·22
Bedford,	Charlesville (30 days),	1,300	. . .	. . .	. . .	70·9	97·0	8	40·0	11	22·3	56·0	26·3	41·5	11	10·5	24	82·9	65·4	1·53
Blair,[2]	Altoona,	1,181	. . .	. . .	. . .	74·1	97·0	8	48·0	21	84·3	63·9	20·4	29·0	18	8·0	25	50·1	54·0	3·22
Blair,	Blue Knob,	2,500	. . .	. .	. . .	70·0	93·0	15	47·0	10	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1·60
Blair,	Hollidaysburg,	947	. . .	. . .	. . .	71·3	98·0	8	43·0	21, 22	86·0	56·0	30·0	44·0	12	14·0	24	84·0	67·0	2·37
Blair,	Tipton,	915	. . .	. . .	. . .	72·6	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1·85
Bradford,	Wysox,	718	30·041	30·344	29·776	68·3	97·0	8	38·0	21	82·1	56·1	26·0	37·0	21	6·5	13	81·4	61·4	3·62
Bradford,	Le Roy,	1,400	. . .	. . .	. . .	69·9	93·0	8	46·0	21	77·9	61·4	16·5	25·0	7	5·0	24	. . .	. . .	2·51
Bucks,	Forks of Neshaminy,	. . .	. . .	. . .	. . .	72·0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·41
Bucks,	Quakertown,	536	30·040	30·260	29·720	69·7	96·0	8	42·0	21	82·1	57·5	24·6	37·2	6	7·5	13	77·4	62·2	5·50
Cambria,[1]	Johnstown,	1,184	30·048	30·319	29·677	71·3	93·0	8	45·0	21	82·8	59·7	23·1	34·0	6	11·0	24	78·3	62·6	1·87
Cameron,	Emporium (27 days),	1,030	. . .	. . .	. . .	74·4	94·0	7, 8	38·0	22	85·4	56·1	29·3	51·0	22	11·0	24	. . .	. . .	4·87
Carbon,[1]	Mauch Chunk,	550	. . .	. . .	. . .	69·0	95·0	·8	42·0	22	81·0	57·0	24·0	35·0	7	8·0	2	. . .	. . .	5·79
Centre,	State College— Agricultural Experiment Station,	1,191	29·981	30·320	29·637	69·7	94·0	8	41·0	21	80·5	58·7	21·8	33·0	11	11·0	24	69·1	58·9	2·44
Centre,	Phillipsburg (24 days),	1,350	. . .	. . .	. . .	65·5	94·0	8	35·0	20	81·9	52·9	29·0	41·0	23	19·0	29	. . .	. . .	0·74
Chester,	West Chester,	455	30·136	30·272	29·685	71·8	96·0	8	51·0	21	81·0	63·0	18·0	26·0	8	7·0	13	71·0	62·0	6·27
Chester,	Coatesville,	380	. . .	. . .	. . .	71·7	99·0	8	45·0	23	84·2	63·5	20·7	35·0	23	7·0	2	. . .	. . .	3·77
Chester,[1]	Kennett Square,	275	. . .	. . .	. . .	70·7	. . .	. . .	. . .	. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5·17
Chester,	Westtown,	350	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Clarion,	Rimersburg,	1,500	. . .	. . .	. . .	75·1	94·0	8	58·0	10	84·7	69·8	14·9	25·0	9	5·0	24	. . .	. . .	. . .
Clarion,	Clarion— State Normal School,	1,530	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Clearfield,	Grampian Hills,	1,450	. . .	. . .	. . .	69·7	96·0	31	42·0	21	81·8	59·2	22·6	34·0	7	8·0	24	. . .	. . .	3·37
Clinton,	Lock Haven,	560	. . .	. . .	. . .	71·1	97·0	8	42·0	21	83·2	57·0	26·2	49·0	15	5·0	2	. . .	. . .	2·85
Columbia,	Catawissa,	491	. . .	. . .	. . .	71·5	96·0	8	48·0	22	82·0	61·0	21·0	33·0	11	8·0	24	. . .	. . .	3·58
Crawford,	Meadville,	1,300	29·950	30·280	29·660	67·8	91·0	31	47·0	21	78·4	. . .	. . .	. . .	. . .	. . .	. . .	76·2	60·1	2·76
Cumberland,	Carlisle (27 days),	480	. . .	. . .	. . .	74·9	101·0	8	43·0	20	88·2	61·2	27·0	38·5	6	11·0	13	53·0	68·0	1·91
Dauphin,[1]	Harrisburg,	361	30·042	30·295	29·725	73·0	96·0	8	50·0	2	82·3	63·2	19·0	29·0	15	5·0	13	63·6	59·3	2·80
Delaware,	Swarthmore— Swarthmore College,	190	30·033	30·240	29·732	72·4	96·0	8	50·0	22	82·0	62·4	19·6	26·7	22	8·0	13	75·0	64·0	3·67
Erie,[1]	Erie,	681	29·990	30·310	29·670	71·0	94·0	8	50·0	21	78·0	63·0	15·0	26·0	17	6·0	9	70·0	60·0	0·76
Fayette,	Uniontown,	1,000	30·030	30·226	29·820	72·9	94·0	8	48·0	10	83·7	62·2	21·5	34·0	6	10·0	18	. . .	. . .	5·65
Forrest,	Tionesta,	1,057	. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Franklin,[1]	Chambersburg— Wilson Female College,	618	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Fulton,	McConnellsburg,	875	. . .	. . .	. . .	71·0	97·0	8	45·0	11	83·8	59·4	24·4	39·0	12	13·0	24	73·8	60·0	3·12
Greene,	Waynesburg,	750	. . .	. . .	. . .	71·4	92·0	8, 15	54·0	20	82·3	65·3	17·0	29·0	12	6·0	23	. . .	. . .	2·50
Huntingdon,[1]	Huntingdon— The Normal College (30 days),	650	. . .	. . .	. . .	69·0	98·0	8	33·0	6	85·5	52·5	33·0	56·0	7	10·0	14	. . .	. . .	4·56
Huntingdon,	Petersburg,	700	. . .	. . .	. . .	70·7	100·0	30	46·0	11	85·4	60·4	25·0	44·0	19	11·0	9	. . .	. . .	5·04
Indiana,	Indiana— State Normal School,	1,350	30·077	30·311	29·828	70·3	94·0	31	41·0	11	83·7	56·1	27·6	40·5	11	16·0	12	70·8	61·3	2·05
Lackawanna,[1]	Scranton,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Lancaster,	Lancaster,	411	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Lawrence,	New Castle,	932	. . .	. . .	. . .	73·4	95·0	8	38·0	21	. . .	55·4	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1·55
Lebanon,	Myerstown,	474	30·011	30·366	29·693	71·7	98·0	8	44·0	11, 22	83·3	59·0	24·3	38·0	11	9·2	24	82·0	65·7	3·36
Lebanon,	Annville— Lebanon Valley College,	339	. . .	. . .	. . .	76·7	102·0	8	62·0	20	. . .	. . .	. . .	. . .	. . .	. . .	. . .	82·4	71·4	. . .
Lehigh,	Coopersburg,	520	. . .	. . .	. . .	70·4	96·0	8	48·0	21	81·1	60·8	20·3	30·0	11	8·0	13	. . .	. . .	5·53
Lehigh,[1]	Lynnport,	350	. . .	. . .	. . .	70·3	96·0	8	43·0	22	83·8	56·8	27·0	44·0	7	9·0	24	. . .	. . .	6·40
Luzerne,	Drifton— Drifton Hospital,	1,653	. . .	. . .	. . .	65·8	92·0	8	45·0	22	77·5	56·9	20·6	33·0	22	10·0	2	. . .	. . .	5·92
Luzerne,[1]	Wilkes-Barre,	575	. . .	. . .	. . .	70·1	98·0	31	41·0	21	83·2	57·0	26·2	38·0	1	15·0	24	. . .	. . .	5·78
Lycoming,[1]	Nisbet,	550	. . .	. . .	. . .	69·0	98·0	8	42·0	21	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3·80
Mercer,[1]	Greenville— Thiel College,	1,000	29·939	30·258	29·648	69·1	95·0	31	38·0	21	82·4	55·9	26·5	39·0	22	13·0	26	89·2	64·6	2·52
Mifflin,	Lewistown,	500	. . .	. .	. . .	74·8	100·0	8	46·0	22	85·8	61·1	24·7	42·0	7	15·0	13	74·9	66·9	2·47
Montgomery,	Pottstown,	150	. .	. .	. . .	72·4	99·0	8	51·0	22	84·9	63·1	21·8	32·0	7	5·0	2	78·0	63·0	5·45
Northampton,	Bethlehem,	360	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Philadelphia,[1]	Philadelphia— Signal Office,	117	30·056	30·287	29·716	74·6	97·0	8	54·0	21	83·4	65·7	17·7	26·0	17	5·0	13	68·4	61·2	4·03
Potter,	Coudersport,	1,670	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Schuylkill,	Girardville,	1,000	30·018	30·232	29·722	69·6	92·0	8	44·0	21	79·0	58·0	21·0	31·0	11	7·0	24	. . .	. .	6·36
Snyder,	Selins Grove,	445	. . .	. . .	. . .	73·5	99·0	8	52·0	21	84·3	62·7	21·6	26·0	22	3·0	2	75·0	59·0	3·58
Somerset,	Somerset,	2,250	. . .	. . .	. . .	67·7	92·0	8, 15	40·0	20, 21	81·4	54·7	26·7	46·0	6	12·0	26	77·2	62·6	2·36
Sullivan,	Eagles Mere,	2,060	30·062	30·368	29·768	66·5	88·0	8	45·0	10	72·9	58·3	14·6	27·0	31	4·0	24	82·0	61·5	4·24
Tioga,	Wellsboro,	1,327	29·992	30·346	29·636	65·2	94·0	8	35·0	21	77·1	56·3	20·8	33·0	21	4·0	24	65·6	58·4	2·65
Union,[1]	Lewisburg,	450	. . .	. . .	. . .	72·6	100·0	8	44·0	21	85·3	60·0	25·3	39·0	11	11·0	24	. . .	. . .	3·79
Warren,	Columbus,	1,410	. . .	. . .	. . .	67·8	92·0	8	36·0	21	80·3	35·2	25·1	44·0	11	8·0	9	65·0	55·2	3·95
Washington,	Canonsburg,	950	30·024	30·250	29·748	70·7	9 ·0	8	40·0	9	83·5	55·5	28·0	41·0	15	11·0	24	79·0	64·0	3·93
Wayne,	Dyberry,	1,100	. .	. .	. . .	64·8	90·0	8	35·0	21	76·6	52·0	24·6	42·0	30	8·0	13	. . .	. . .	4·45
Wayne,	Honesdale,	1,000	. . .	. . .	. . .	66·5	89·0	8	40·0	21	76·6	56·5	20·1	32·0	7	5·0	2	64·8	57·0	4·73
Westmoreland,	Ligonier,	1,750	. . .	. . .	. . .	73·4	94·0	8	40·0	21	85·0	57·0	28·0	42·0	11	3·0	9	70·0	59·0	2·47
Wyoming,[1]	South Eaton	660	. . .	. . .	. . .	68·4	92·0	8	43·0	21	78·3	58·5	19·8	31·0	9	6·0	2	. . .	. . .	2·72
York,[1]	York,	385	29·973	30·225	29·736	72·7	101·0	8	43·0	21	85·2	60·2	25·0	36·5	22	6·0	5	74·6	63·2	1·77

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

	Gettysburg.	Lewistown.	Greensburg.	Tipton.	Coudersport.	Coopersburg.	Westtown.	Meadville.	Ligonier.	Scranton.
	. .	. .	. .	·80	. .	. .	. .	. .	·25	. .
	·26	·77	. .	. .	. .	1·70	. .	·58	. .	. .
	·08	·32	. .	. .	. .	·40	. .	. .	. .	. .
	·10	·05	. .	·70	. .	. .	. .	·56	·40	. .
	. .	. .	. .	. .	. .	·01	. .	. .	. .	. .
	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	. .	. .	. .	. .	. .	. .	. .	·35	. .	. .
	. .	·04	. .	. .	. .	. .	. .	·44	. .	. .
	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	·06	. .	. .	. .	. .	·08	. .	. .	. .	. .
	. .	. .	. .	·12	. .	·08	. .	. .	·10	. .
	. .	·42	. .	. .	. .	. .	. .	. .	. .	. .
	. .	·02	. .	·11	. .	·44	. .	. .	. .	. .
	·11	·02	. .	. .	. .	. .	. .	. .	. .	. .
	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	1·03	·20	. .	·12	. .	·24	. .	·10	1·27	. .
	·40	·20	. .	. .	. .	·97	. .	·37	·01	. .
	·55	·42	. .	. .	. .	1·01	. .	. .	·37	. .
	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	·17	·01	. .	. .	. .	·31	. .	. .	·07	. .
	·02	. .	. .	. .	. .	·29	. .	. .	. .	. .
	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	. .	. .	. .	. .	. .	. .	. .	·36	. .	. .
	2·73	2·47	. .	1·85	. .	5·53	. .	2·76	2·47	. .

T. F. T.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for July, 1890:

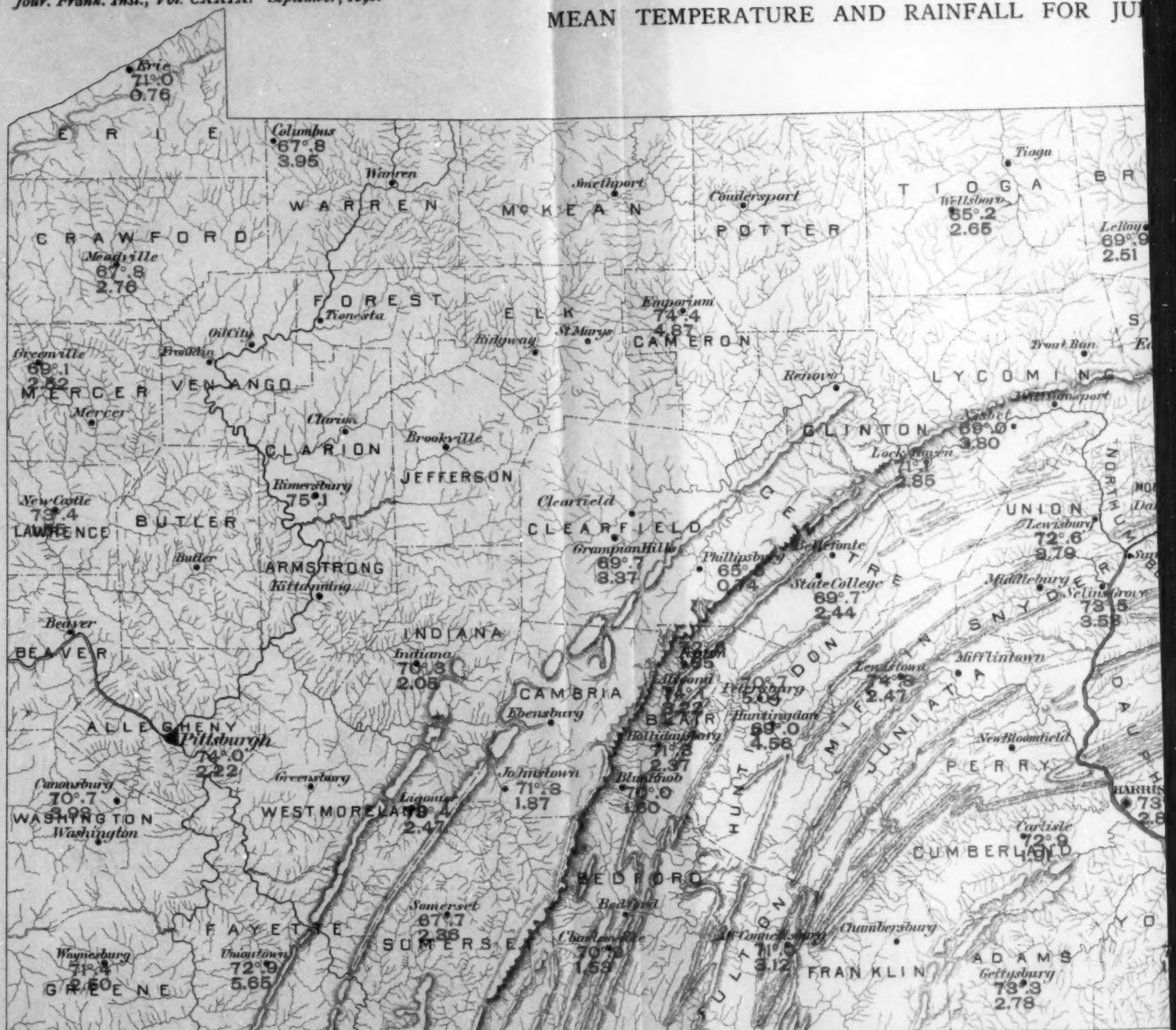
Weather, 86 per cent.
Temperature, 91 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.

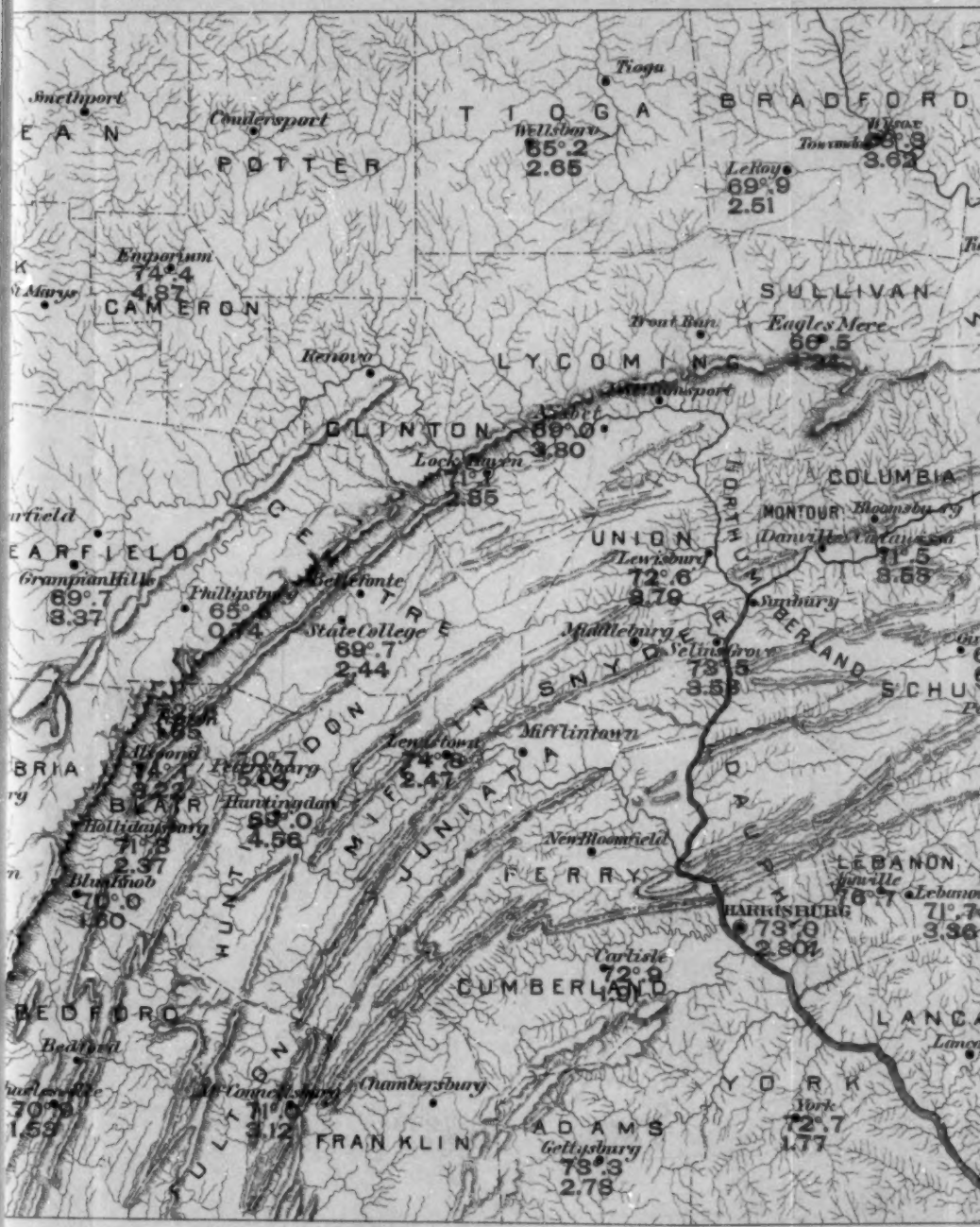
Displayman.	*Station.*
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
Raftsman's Journal,	Clearfield.
R. C. Schmidt & Co.,	Belle Vernon.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
C. A. Hinsdell,	Scranton.
H. M. Kaisinger,	Hartsville.
E. Jennet,	Franklin.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.
Wister Heberton & Co.,	Germantown.
Charles M. Mullen,	Bedford.
E. W. Merrill,	North East.
A. Simon's Sons,	Lock Haven.
Frank Ridgway,	Harrisburg.
G. W. Yost,	Collegeville.
A. C. Tryon,	Spartansburg.

MEAN TEMPERATURE AND RAINFALL FOR JU



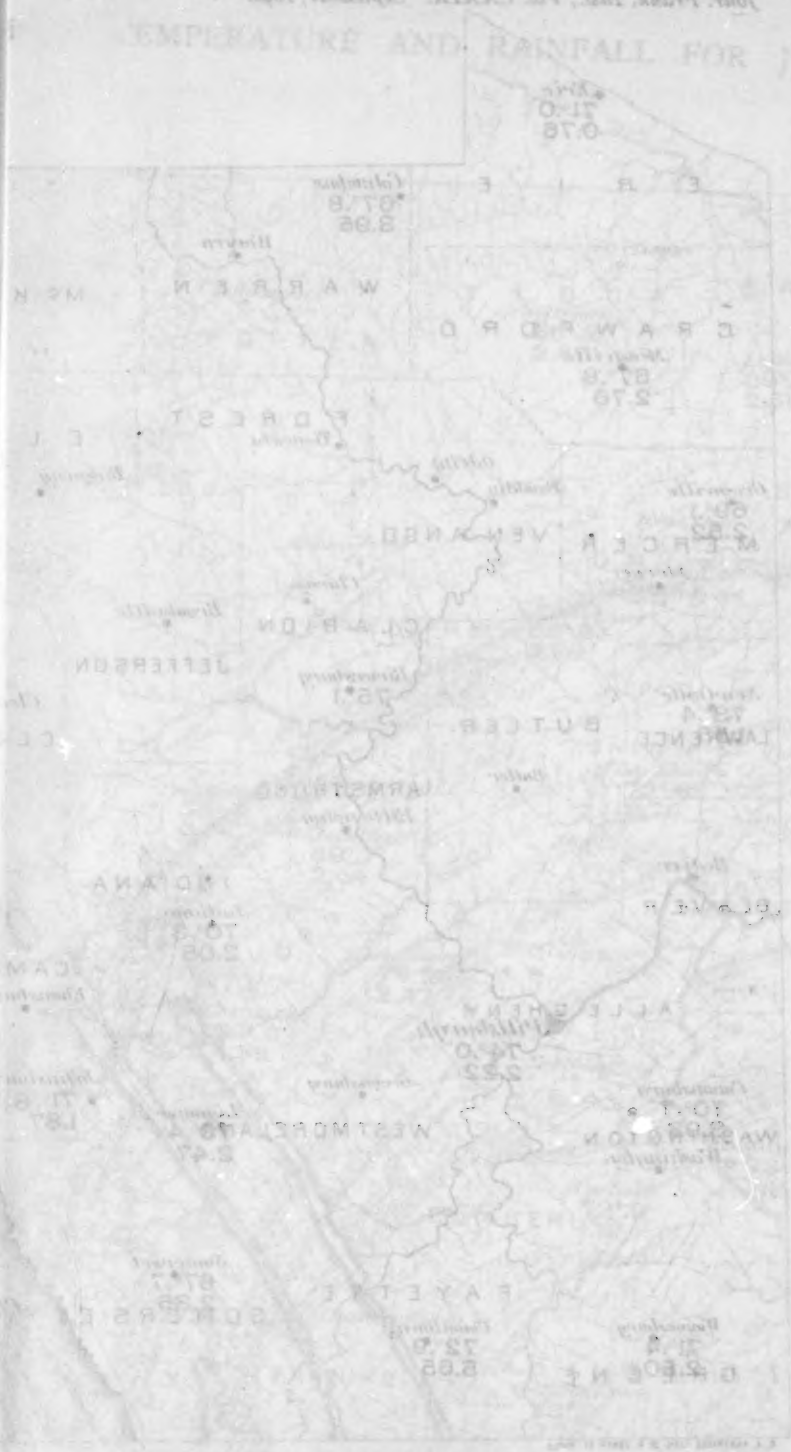
E. A. PARTRIDGE, LITH. 33 S. TENTH ST. PHILA.

MEAN TEMPERATURE AND RAINFALL FOR JULY, 1890.



1890.

Montrose
SUSQUEHANNA
WAYNE
Honesdale
66°.5
4.73
Tunkhannock
South Canaan
68°.4
2.70
Scranton
WYOMING
LACKAWANNA
Bloomingrove
Milford
PIKE
Wilkesbarre
70°.1
5.28
LUZERNE
MONROE
Stroudsburg
Drifton
65°.8
5.92
CARBON
Manch Chunk
69°.0
5.79
NORTHAMPTON
Easton
Girardville
69°.6
6.36
SCHUYLKILL
Pottsville
Lynnport
70°.3
6.45
Bethlehem
LEHIGH
Allentown
Hamburg
70°.4
5.38
Quakertown
69°.7
5.50
BERKS
Reading
BUCKS
Doylestown
Lebanon
71°.7
3.36
MONTGOMERY
Pottstown
72°.4
5.45
Norristown
Hatboro
LANCASTER
Lancaster
CHESTER
Coatesville
71°.7
3.77
West Chester
71°.8
Swarthmore
72°.2
3.67
DELAWARE
Kennett Square
70°.7
5.17



PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR AUGUST, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, August 31, 1890.

TEMPERATURE.

The mean temperature of 58 stations for August, 1890, was 68°.4, which is about 2°.0 below the normal, and 1°.1 above the corresponding month of 1889.

The mean of the daily maximum and minimum temperatures 79°.2 and 58°.5 give an average daily range of 20°.7, and a monthly mean of 68°.8.

Highest monthly mean, 73°.6 at Philadelphia.

Lowest monthly mean, 60°.1 at Wellsboro.

Highest temperature recorded during the month, 98° on the 3d at New Castle, and on the 6th at Gettysburg.

Lowest temperature, 34° on the 24th at Somerset.

Greatest local monthly range, 29°.5 at Huntingdon.

Least local monthly range, 13°.0 at Erie.

Greatest daily range, 47° at New Castle on the 16th.

Least daily range, 2°.0 at Grampian Hills on the 21st.

From January 1, 1890, to August 31, 1890, the excess in temperature at Philadelphia was 670°, at Erie 276° and at Pittsburgh 659°.

The warmest period of the month was from the 1st to the 4th, inclusive, and on the 17th, 18th and 19th. The coldest was on the 24th and 31st.

Light frosts were reported in several of the elevated districts on the 24th.

BAROMETER.

The mean pressure for the month, 30.03, is about .05 above the normal. At the U. S. Signal Service Stations, the highest observed was 30.28 at Pittsburgh on the 24th, and the lowest 29.680 at Philadelphia on the 27th.

PRECIPITATION.

The average rainfall 5.76 inches for the month, is an excess of over 1.50 inches. The distribution was unevenly divided.

The largest monthly totals in inches were Carlisle, 9.65; Ligonier, 9.37; Gettysburg, 8.95; Mauch Chunk, 8.59; Uniontown, 8.44.

The smallest were Charlesville, 2·58; Philadelphia, 3·36; New Castle, 3·69; Pottstown, 3·80; Lock Haven, 3·83; Hollidaysburg, 3·87, and Meadville, 3·94.

Rains were of almost daily occurrence in some parts of the State. The heaviest occurred on the 8th, 18th, 19th, 20th, 21st, 22d, 26th and 27th.

On the 8th, Gettysburg reports a fall of 4·98 inches, and Carlisle, 3·04 inches.

WIND AND WEATHER.

The prevailing wind was from the west.

Local storms of great severity were numerous and destructive to life and property. The most notable occurred on the 19th, when at about 5·12 P. M. a terrific tornado from the Southwest passed over Wilkes-Barre. Sixteen persons were killed, and the damage to property is estimated at one million of dollars.

Average number: Rainy days, 12; clear days, 9; fair days, 14; cloudy days, 8.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Gettysburg, 5th, 19th, 29th; Charlesville, 5th, 21st; Blue Knob, 1st, 3d, 5th, 9th, 17th, 19th, 21st, 22d, 29th; Hollidaysburg, 29th; Le Roy, 5th, 9th, 17th, 19th; Forks of Neshaminy, 1st, 5th, 21st; Quakertown, 5th, 10th, 14th, 17th, 19th, 21st, 26th, 29th; Johnstown, 1st, 5th, 17th, 19th, 21st, 22d, 29th; Emporium, 1st, 5th, 9th, 17th, 19th, 21st, 29th; State College, 1st, 5th, 19th, 29th; Phillipsburg, 19th; West Chester, 1st, 6th, 18th, 19th, 21st, 29th; Coatesville, 1st, 8th, 10th, 14th, 18th; Kennett Square, 1st, 14th, 18th, 19th, 20th, 21st, 29th; Rimersburg, 5th, 9th, 17th, 29th; Grampian Hills, 12th; Lock Haven, 1st, 5th, 9th, 18th, 20th, 23d, 26th, 29th; Catawissa, 5th, 10th, 17th, 19th, 21st, 22d, 29th; Meadville, 1st, 3d, 4th, 5th, 17th, 19th, 21st, 22d; Carlisle, 1st, 5th, 21st, 29th; Harrisburg, 5th, 14th, 29th; Swarthmore, 1st, 5th, 10th, 18th, 19th, 21st, 22d, 30th; Erie, 4th, 21st, 29th; McConnellsburg, 1st; Waynesburg, 5th, 7th, 17th, 18th, 19th, 20th, 21st, 22d, 26th; Huntingdon, 1st, 5th, 21st, 22d, 29th; Petersburg, 5th, 22d; Myerstown, 14th, 17th, 19th, 21st, 22d, 29th; Coopersburg, 1st, 5th, 10th, 13th, 14th, 17th, 19th, 21st, 26th, 29th; Drifton, 5th, 10th; Wilkes-Barre, 17th, 18th, 19th, 26th; Nisbet, 1st, 5th, 8th, 17th, 19th, 21st, 23d, 26th, 29th; Greenville, 22d; Pottstown, 1st, 10th, 21st, 29th; Bethlehem, 2d, 5th, 6th, 10th, 13th, 17th, 19th, 21st, 29th; Philadelphia, 1st, 19th, 21st, 22d; Girardville, 5th, 21st, 29th; Selins Grove, 4th, 9th, 14th, 17th, 19th, 21st, 22d, 29th; Somerset, 16th, 17th, 21st, 22d; Eagles Mere, 3d, 9th, 29th; Wellsboro, 1st, 3d, 5th, 9th, 17th, 19th, 21st, 29th; Lewisburg, 1st, 5th, 9th, 17th, 19th, 21st, 22d; Columbus, 1st, 4th, 5th, 9th, 17th; Canonsburg, 22d, 29th; Dyberry, 1st, 6th, 10th, 17th, 19th, 22d, 26th; Ligonier, 1st, 5th, 19th, 29th; South Eaton, 2d, 5th, 9th, 10th, 14th, 17th, 19th, 21st, 22d, 26th, 29th; York, 1st, 6th, 8th, 14th, 18th, 19th, 21st, 22d, 25th, 26th, 30th; Phœnixville, 10th, 13th, 17th, 19th, 21st, 23d, 26th, 29th, 30th.

Hail.—Charlesville, 1st; Forks of Neshaminy, 1st, 5th; Huntingdon, 1st, 2d; Petersburg, 22d; Philadelphia, 1st, Lewisburg, 1st; Canonsburg, 29th.

County.

Adams,[1]
Allegheny,[1]
Bedford,
Blair,[8]
Blair,
Blair,
Blair,
Bradford,
Bradford,
Bucks,
Bucks,
Cambria,[1]
Cameron,
Carbon,[1]
Centre,

Centre,
Chester,
Chester,
Chester,[1]
Chester,
Chester,
Clarion,
Clarion,

Clearfield,
Clinton,
Columbia,
Crawford,
Cumberland,
Dauphin,[1]
Delaware,

Erie,[1]
Fayette,
Franklin,[1]

Fulton,
Greene,
Huntingdon,[1]

Huntingdon,
Indiana,

Lackawanna,[1]
Lancaster,
Lawrence,
Lebanon,
Lebanon,

Lehigh,
Lehigh,[1]
Luzerne,

Luzerne,[1]
Lycoming,[1]
Mercer,[1]

Mifflin,
Montgomery,
Northampton,
Philadelphia,[1]

Schuylkill,
Snyder,
Somerset,
Sullivan,
Tioga,
Union,[1]
Warren,
Washington,
Wayne,
Wayne,
Westmoreland,
Wyoming,[1]
York,[1]

[1] Observations t

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Serv

County.	Station.	Elevation above Sea Level (feet).	Barometer Reduced to Sea Level.			Temperature.											Relative Humidity.	Dew Point.	Precipitat	
							Maximum.		Minimum.				Daily Range.							
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.			Total Inches.	Number of Days
dams,[1]	Gettysburg,	624	. . .	. . .	. . .	70·3	98·0	6	40·0	24	82·4	58·3	24·1	33·0	24	7·0	18	. . .	. . .	8·95	13
legheny,[1]	Pittsburgh,	847	30·050	30·280	29·720	71·1	94·0	2	45·0	24	80·0	62·2	17·8	31·0	16	7·0	14	68·2	58·0	4·06	12
dford,	Charlesville (30 days),	1,300	. . .	. . .	. . .	67·4	89·0	1	37·0	24	78·0	55·3	22·7	34·0	13	3·0	14	72·8	55·7	2·38	8
air,[2]	Altoona,	1,181	. . .	. . .	. . .	72·0	94·0	4	51·0	31	81·4	62·6	18·8	26·0	16	9·0	18	56·4	55·5	4·09	10
air,	Blue Knob,	2,500	. . .	. . .	. . .	66·0	94·0	3	44·0	31	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	6·00	11
air,	Hollidaysburg,	947	. . .	. . .	. . .	68·0	96·0	2, 3	43·0	31	82·3	55·4	26·9	39·0	13	13·0	18	79·0	62·0	3·87	9
air,	Tipton,	915	. . .	. . .	. . .	69·2	. . .	. . .	52·0	31	85·4	62·0	23·4	37·0	2	4·0	22	. . .	. . .	4·85	10
adford,	Wysox,	718	30·043	30·272	29·725	66·3	91·0	4	42·0	24	77·9	56·2	21·7	33·5	16	10·0	23	81·8	61·0	5·71	13
adford,	Le Roy,	1,400	. . .	. . .	. . .	67·5	88·0	2, 3	45·0	24	74·9	59·9	15·0	25·0	16	6·0	23	. . .	. . .	5·71	13
cks,	Forks of Neshaminy,	. . .	. . .	. . .	. . .	70·9	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5·00	10
cks,	Quakertown,	536	30·030	30·240	29·640	68·5	90·0	1	43·0	24	79·9	58·5	21·4	32·5	25	12·2	2	82·0	62·8	5·86	14
mbria,[1]	Johnstown,	1,184	30·071	30·284	29·775	68·8	94·0	3	44·0	24	78·5	59·2	19·3	31·0	12	11·0	18	86·2	61·5	6·38	13
meron,	Emporium	1,030	. . .	. . .	. . .	68·9	92·0	2	35·0	31	79·1	53·9	25·2	40·0	16	12·0	1	. . .	. . .	7·76	13
rbon,[1]	Mauch Chunk,	550	. . .	. . .	. . .	68·4	91·0	9	46·0	24, 25	79·5	57·4	22·1	33·0	9	10·0	3	. . .	. . .	8·59	11
ntre,	State College— Agricultural Experiment Station,	1,191	29·997	30·234	29·710	66·6	90·0	2	44·0	24	76·9	57·9	19·0	29·0	13	9·0	8	74·8	57·4	5·46	11
ntre,	Phillipsburg,	1,350	. . .	. . .	. . .	64·3	94·0	2	39·0	12	79·7	53·2	26·5	44·0	12	15·0	19	. . .	. . .	4·33	13
nester,	West Chester,	455	30·025	30·215	29·655	70·0	91·0	1	46·0	24	78·9	63·3	15·6	23·0	24	5·0	8	77·5	62·0	5·87	17
nester,	Coatesville,	380	. . .	. . .	. . .	70·4	95·0	1	42·0	24	82·3	60·8	21·5	35·0	25	3·0	8	. . .	. . .	4·77	14
nester,[1]	Kennett Square,	275	. . .	. . .	. . .	69·0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	7·40	16
nester,	Phœnixville, (27 days).	. . .	30·028	30·260	29·660	70·5	89·0	17, 19	46·0	24	80·3	62·6	17·7	25·5	24	9·0	8	84·0	66·0	4·94	14
nester,	Westtown,	350	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
arion,	Rimersburg,	1,500	. . .	. . .	. . .	68·5	93·0	2, 3	40·0	31	76·1	62·4	13·7	26·0	13	4·0	21	. . .	. . .	. . .	. .
arion,	Clarion— State Normal School,	1,530	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
earfield,	Grampian Hills,	1,450	. . .	. . .	. . .	66·1	94·0	4	46·0	24	77·5	59·0	18·5	30·0	29	2·0	21	. . .	. . .	6·41	12
inton,	Lock Haven, (30 days).	560	. . .	. . .	. . .	70·9	94·0	4	41·0	24	82·5	58·9	23·6	41·0	12	10·0	5	. . .	. . .	3·83	9
olumbia,	Catawissa,	491	. . .	. . .	. . .	69·8	90·0	4, 17	43·0	24	78·8	60·6	18·2	27·0	16	9·0	22	. . .	. . .	5·44	13
awford,	Meadville,	1,300	29·958	30·160	29·550	63·9	91·0	3	. . .	. . .	74·5	53·3	21·2	. . .	. . .	. . .	. . .	77·8	56·8	3·94	7
mberland,	Carlisle,	480	. . .	. . .	. . .	69·5	92·0	1, 18	44·0	24	82·7	61·0	21·7	32·0	12	6·5	18	89·0	66·0	9·65	14
auphin,[1]	Harrisburg,	361	30·046	30·270	29·756	70·4	88·0	1	50·0	24	79·3	63·1	16·2	24·0	1	8·0	18	72·6	60·6	5·70	15
elaware,	Swarthmore— Swarthmore College (27 days),	190	30·026	30·232	29·743	72·2	91·0	1	50·0	31	81·3	64·6	16·7	26·4	1	6·4	8	82·3	66·9	4·38	10
ie,[1]	Erie,	681	30·030	30·240	29·730	67·0	89·0	3	47·0	24	73·0	60·0	13·0	23·0	16	4·0	30	73·0	58·0	4·64	12
ayette,	Uniontown,	1,000	30·028	30·184	29·735	71·6	95·0	3	43·0	24, 31	80·4	61·6	18·8	36·0	31	8·0	14	. . .	. . .	8·44	9
anklin,[1]	Chambersburg— Wilson Female College,	618	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
lton,	McConnellsburg,	875	. . .	. . .	. . .	68·9	92·0	27	40·0	24	81·4	59·0	22·4	33·0	24	13·0	18	77·3	62·3	6·60	11
eene,	Waynesburg,	750	. . .	. . .	. . .	67·1	94·0	3	40·0	31	78·7	55·5	23·2	. . .	. . .	. . .	. . .	. . .	. . .	5·45	9
untingdon,[1]	Huntingdon— The Normal College,	650	. . .	. . .	. . .	68·6	93·0	1	40·0	31	83·4	53·9	29·5	39·0	30	19·0	26	. . .	. . .	4·40	9
untingdon,	Petersburg,	710	. . .	. . .	. . .	69·4	96·0	2	46·0	24	82·7	60·8	21·9	40·0	13	8·0	14	. . .	. . .	4·38	12
diana,	Indiana— State Normal School,	1,350	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
ckawanna,[1]	Scranton,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
ncaster,	Lancaster,	413	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
wrence,	New Castle,	932	. . .	. . .	. . .	69·6	98·0	3	36·0	31	80·3	54·0	26·3	47·0	16	10·0	30	. . .	. . .	3·69	7
banon,	Myerstown,	474	29·998	30·166	29·749	69·0	92·0	1	40·0	24	81·4	59·5	21.9	31·2	24	8·5	8	86·4	55·0	5·12	15
banon,	Annville— Lebanon Valley College,	339	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
high,	Coopersburg,	520	. . .	. . .	. . .	68·8	91·0	4	50·0	25	78·9	62·0	16·9	2·60	14	9·0	3	. . .	. . .	6·72	14
high,[1]	Lynnport,	350	. . .	. . .	. . .	70·2	92·0	1	41·0	24	81·9	58·5	23·4	31·0	15	13·0	31	. . .	. . .	6·50	. .
zerne,	Drifton— Drifton Hospital,	1,655	. . .	. . .	. . .	64·8	88·0	2, 4	42·0	24	75·5	57·2	18·4	26·0	11	10·0	8	. . .	. . .	5·30	12
zerne,[1]	Wilkes-Barre,	575	. . .	. . .	. . .	69·0	91·0	17	41·0	24	80·5	57·5	23·0	31·5	25	13·0	23	. . .	. . .	5·44	12
rcoming,[1]	Nisbet,	550	. . .	. . .	. . .	67·7	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·30	9
rcer,[1]	Greenville— Thiel College,	1,000	29·964	30·200	29·636	66·0	96·0	4	37·0	31	78·1	53·9	24·2	43·2	16	13·3	26	87·4	53·4	4·28	13
ifflin,	Lewistown,	500	. . .	. .	. . .	172·2	93·0	4	43·0	23	79·8	58·1	21·7	34·0	12	12·0	10	85·3	68·1	5·27	15
ontgomery,	Pottstown,	150	. .	. . .	. . .	70·9	94·0	1	50·0	23, 25	82·6	63·4	19·2	32·0	25	8·0	8	82·0	64·0	3·80	13
rthampton,	Bethlehem,	360	. . .	. . .	. . .	72·1	89·0	4	49·0	23	80·1	62·3	17·8	26·0	22	10·0	28	82·0	66·0	5·31	7
iladelphia,[1]	Philadelphia— Signal Office,	117	30·046	30·260	29·680	73·6	94·0	1	51·0	24	81·3	66·0	15·3	22·0	17	5·0	23	90·0	63·0	3·36	12
huylkill,	Girardville,	1,000	30·007	30·182	29·750	67·0	85·0	4, 17	45·0	24	76·0	58·0	18·0	25·0	15	8·0	26	. . .	. . .	6·48	14
yder,	Seiins Grove,	445	. . .	. .	. . .	70·0	94·0	4	. . .	. .	83·7	56·3	27·4	. . .	. . .	. . .	. . .	80·3	63·6	5·81	13
merset,	Somerset,	2,250	. . .	. . .	. . .	65·4	93·0	3	34·0	24	77·9	53·6	24·3	38·0	16	10·0	18	86·2	60·2	7·90	12
llivan,	Eagles Mere,	2,060	30·070	30·290	29 829	64·0	82·0	4	41·0	24	70·7	57·0	13·7	25·0	2	4·0	19	70·8	52·4	7·28	13
oga,	Wellsboro,	1,327	30·064	30·234	29·710	60·1	88·0	4	40·0	12	71·5	52·4	19·1	30·0	7	16·0	3	68·5	56·8	6·89	16
ion,[1]	Lewisburg,	450	. . .	. . .	. . .	70·8	93·0	4	42·0	24	82·1	59·5	22·6	34·0	13	12·0	30	. . .	. . .	5·78	13
arren,	Columbus,	1,410	. . .	. . .	. . .	64·6	95·0	3	40·0	24	76·0	53·2	22·8	40·0	16	7·0	5	68·0	53·0	6·20	16
ashington,	Canonsburg,	950	30·040	30·288	29·136	67·3	. . .	. . .	39·0	24	78·5	55·1	22·4	. . .	. . .	. . .	. . .	79·0	60·5	6·89	14
ayne,	Dyberry,	1,100	. . .	. . .	. . .	63·1	86·0	4	40·0	24, 25	74·0	53·5	20·5	34·0	16	6·0	23	. . .	. . .	6·35	14
ayne,	Honesdale,	1,000	. . .	. . .	. . .	65·9	87·0	4	41·0	24	74·8	57·0	17·8	30·0	16	4·0	23	64·8	57·3	5·97	15
estmoreland,	Ligonier,	1,750	. . .	. . .	. . .	68·7	96·0	3	38·0	24	80·5	54·3	26·2	38·0	12	13·0	10	76·0	62·0	9·37	10
yoming,[1]	South Eaton	660	. . .	. . .	. . .	67·4	88·0	4	47·0	24	75·9	58·9	17·0	25·0	16	7·0	23	. . .	. . .	7·53	17
rk,[1]	York,	385	29·968	30·171	29·797	71·5	93·0	1, 17	42·0	24	80·6	60·5	22·1	30·0	29	4·5	8	79·4	63·7	5·65	15

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

Frost.—Blue Knob, 24th; Catawissa, 24th; Waynesburg, 24th, 31st; Girardville, 24th, 28th; Somerset, 12th, 24th; Wellsboro, 13th, 16th, 24th; Lewisburg, 24th.

Sleet—Wellsboro, 17th.

Coronæ.—Charlesville, 1st.

Solar Halos.—Le Roy, 6th; Meadville, 16th, 17th, 18th; Eagles Mere, 16th; Phœnixville, 28th.

Lunar Halos.—West Chester, 28th; Carlisle, 30th; Coopersburg, 28th; Girardville, 28th; York, 28th; Phœnixville, 28th.

Meteors.—Blue Knob, 10th, 15th, 27th; Rimersburg, 10th; Meadville, 6th; Eagles Mere, 6th; Phœnixville, 9th, 10th, 16th.

Lunar Rainbow.—Greenville, 29th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for August, 1890:

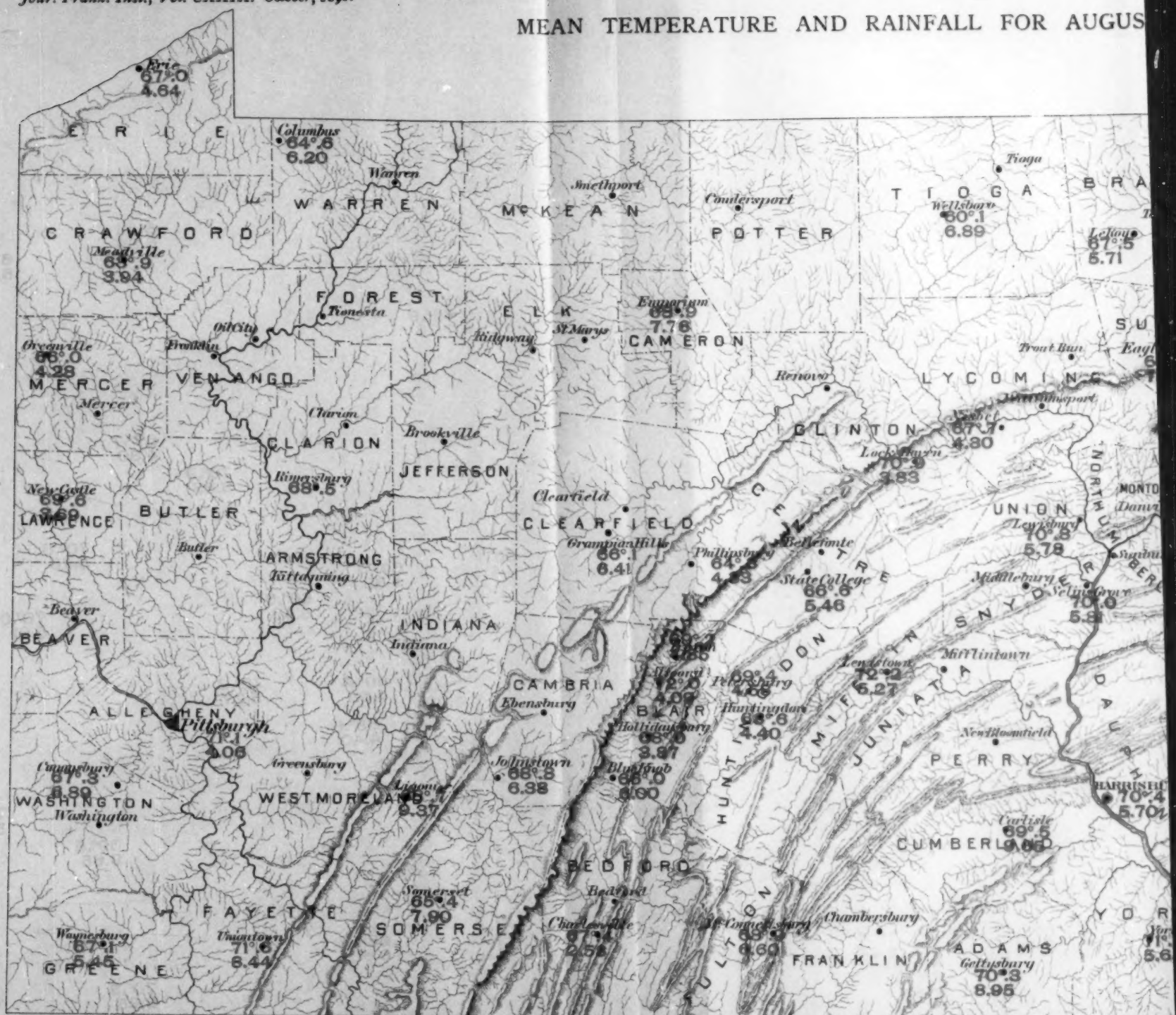
Weather, 82 per cent.
Temperature, 85 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
D. G. Hurley,	Altoona.

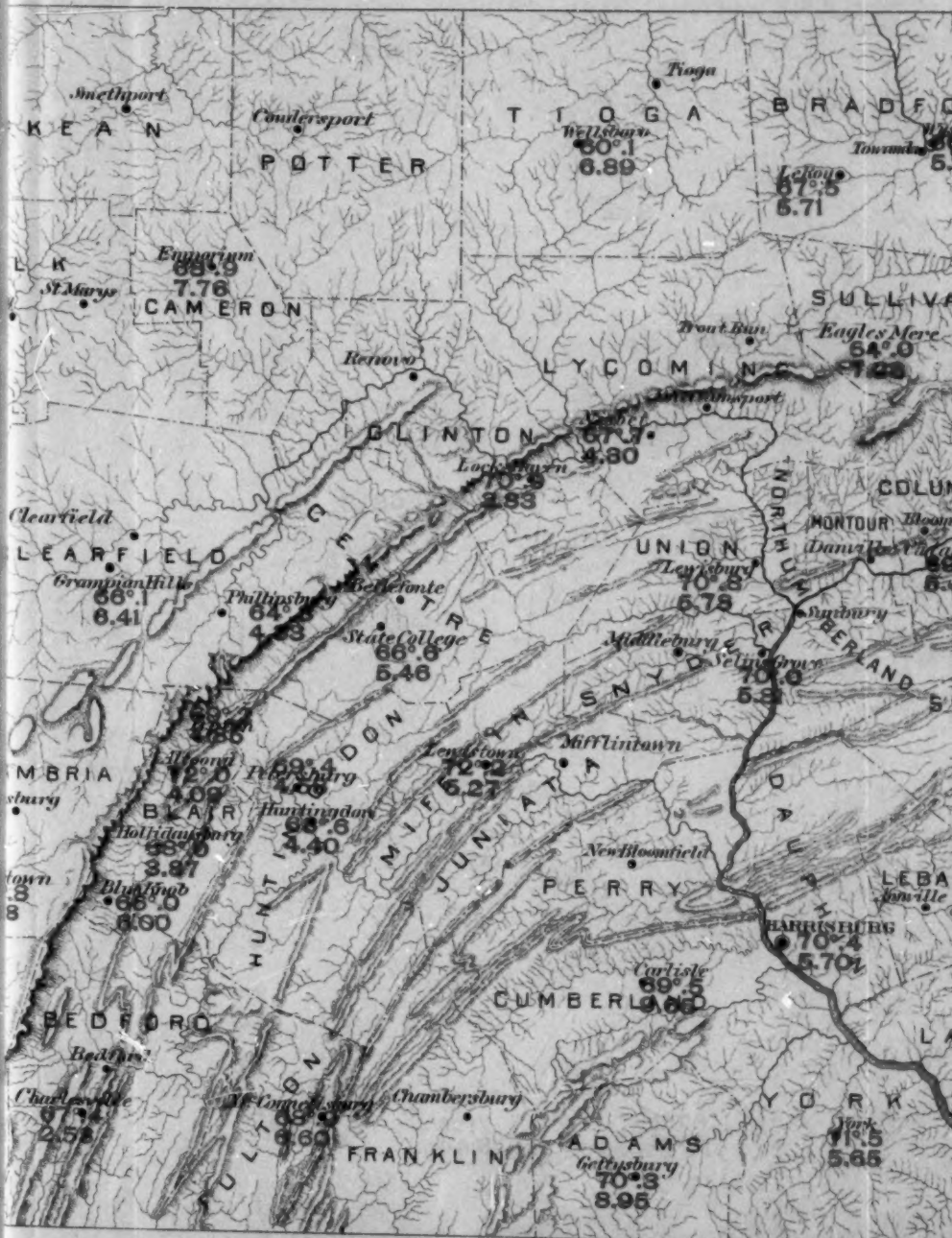
Displayman.	*Station.*
J. E. Forsythe,	Butler.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
Raftsman's Journal,	Clearfield.
R. C. Schmidt & Co.,	Belle Vernon.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
C. A. Hinsdell,	Scranton.
H. M. Kaisinger,	Hartsville.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.
Wister Heberton & Co.,	Germantown.
Charles M. Mullen,	Bedford.
E. W. Merrill,	North East.
A. Simon's Sons,	Lock Haven.
Frank Ridgway,	Harrisburg.
G. W. Yost,	Collegeville.
A. C. Tryon,	Spartansburg.
A. H. Gerbench,	Annville.
Knowles Croskey,	Phoenixville.

MEAN TEMPERATURE AND RAINFALL FOR AUGUS



D. A. PARTRIDGE LITH. 20 S. TENTH ST. PHILA.

MEAN TEMPERATURE AND RAINFALL FOR AUGUST, 18



ST, 1890.

Montrose
SUSQUEHANNA
WAYNE
Honesdale
65°.9
5.97
Tunkhannock
South Eaton
67°.4
7.88
Scranton
Bloomsburg
Milford
PIKE
WYOMING
LACKAWANNA
LUZERNE
COLUMBIA
MONROE
Stroudsburg
Bloomsburg
Drifton
64°.8
5.30
CARBON
Mauch Chunk
68°.4
8.59
NORTHAMPTON
Easton
Shamokin
67°.0
6.48
SCHUYLKILL
Pottsville
Lynnport
70°.2
6.55
HIGH
Bethlehem
72°.1
8.31
Allentown
Hamburg
Quakertown
68°.5
BERKS
Reading
Doylestown
LEBANON
Lebanon
69°.0
5.12
MONTGOMERY
Pottstown
70°.9
3.80
Norristown
Plumsteadville
70°.5
LANCASTER
CHESTER
West Chester
70°.0
DELAWARE
Kennett Square
69°.0
7.40

TEMPERATURE AND RAINFALL FOR AUGUS
67°.0
4.64
64°.8
6.20
68°.9
3.84
66°.0
4.28
68°.6
66°.6
3.69
71°.4
4.09
67°.3
8.59
68°.8
6.38
68°.7
6.37
65°.4
7.90
71°.6
8.44
67°.1
5.45

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR SEPTEMBER, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, September 30, 1890.

TEMPERATURE.

The mean temperature of 57 stations for September, 1890, was 62°·0, which is about 1°·0 above the normal, and 0°·1 above the corresponding month of 1889.

The mean of the daily maximum and minimum temperatures 72°·4 and 52°·1 give an average daily range of 20°·3, and a monthly mean of 62°·2.

Highest monthly mean, 67°·2 at Philadelphia.

Lowest monthly mean, 56°·4 at Wellsboro, Dyberry, and Waynesburg.

Highest temperature recorded during the month, 91° on the 5th at Coatesville and Carlisle, and on the 7th at McConnellsburg.

Lowest temperature, 25° on the 25th at Dyberry.

Greatest local monthly range, 26°·4 at Phillipsburg.

Least local monthly range, 14°·0 at Erie.

Greatest daily range, 49°·0 at Huntingdon on the 20th.

Least daily range, 1°·0 at Drifton on the 11th, Selins Grove 14th, and Columbus 27th.

From January 1, 1890, to September 30, 1890, the excess in temperature at Philadelphia was 681°, at Erie 183° and at Pittsburgh 652°.

The warmest period of the month was from the 2d to the 8th, inclusive. The coldest was from the 25th to the end of the month.

Frosts were quite general on the 25th, 28th, 29th, and 30th.

BAROMETER.

The mean pressure for the month, 30·135, is about ·05 above the normal. At the U. S. Signal Service Stations, the highest observed was 30·39 at Pittsburgh and Erie on the 28th, and the lowest 29·80 at Erie on the 13th.

PRECIPITATION.

The average rainfall 4·57 inches for the month, is an excess of one inch.

The largest monthly totals in inches were Ligonier, 8·54; Indiana, 8·10; Somerset, 7·84; Emporium, 7·91; New Castle, 7·48; and Columbus, 7·10.

The least were South Eaton, 2·05; State College, 2·29; Philadelphia, 2·31; Petersburg, 2·35; Wilkes-Barre, 2·42; Swarthmore, 2·62; McConnellsburg, 2·62 and Harrisburg, 2·89.

General rains occurred from the 11th to the 15th inclusive, and on the 26th and 27th. Excessive rains were reported from Wellsboro on the 9th and 10th; Myerstown and Meadville on the 11th and 12th, and at York on the 12th and 13th.

NOTE.—An actual fall of 2·50 inches in any period of 24 hours, or one inch in one hour, is excessive precipitation.

WIND AND WEATHER.[1]

The prevailing wind was from the northwest. The weather was generally favorable for the harvesting and curing of late crops, and for fall seeding.

Average number: Rainy days, 11; clear days, 10; fair days, 9; cloudy days, 11.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Charlesville, 5th; Blue Knob, 5th, 7th, 8th, 9th, 10th, 11th, 12th, 16th; Hollidaysburg, 8th, 16th, 24th; Tipton, 4th, 8th, 16th; Le Roy, 16th; Quakertown, 5th, 12th, 13th, 16th; Johnstown, 8th, 9th, 16th; Emporium, 5th, 12th, 16th; Mauch Chunk, 7th; State College, 16th; West Chester, 5th, 12th; Coatesville, 5th, 12th; Kennett Square, 5th, 6th, 12th, 16th; Phœnixville 16th, 17th; Westtown, 5th; Rimersburg, 11th, 15th, 16th; Catawissa, 5th, 16th; Meadville, 3d, 8th, 11th, 15th; Carlisle, 16th; Harrisburg, 16th; Swarthmore, 6th, 13th, 15th, 17th; Uniontown, 5th, 6th, 7th, 8th; Petersburg, 16th; Indiana, 7th, 9th, 10th, 16th; Myerstown, 12th, 13th; Coopersburg, 12th, 13th; Philadelphia, 6th, 15th; Girardville, 12th, 16th; Selins Grove, 12th, 13th; Somerset, 7th; Wellsboro, 9th, 16th; Lewisburg, 5th, 12th, 16th; Columbus, 16th; Dyberry, 7th, 12th, 13th; Ligonier, 5th, 9th; South Eaton, 5th, 16th; York, 5th, 12th.

Hail.—Johnstown, 16th.

Snow.—Blue Knob, 20th.

Frost.—Pittsburgh, 28th, 29th; Charlesville, 25th, 29th; Altoona, 24th, 25th, 27th, 28th; Blue Knob, 1st, 24th, 25th, 28th, 29th, 30th; Hollidaysburg, 25th, 28th, 29th; Tipton, 1st, 2d, 25th, 28th, 29th; Wysox, 28th; Le Roy, 25th, 29th, 30th; Forks of Neshaminy, 25th; Quakertown, 25th, 29th, 30th; Emporium, 28th; State College, 25th, 28th, 29th, 30th; Phillipsburg, 1st, 21st, 22d, 23d, 24th, 25th, 28th, 29th, 30th; Coatesville, 25th, 29th, 30th; Phœnixville, 25th, 29th, 30th; Westtown, 25th; Rimersburg, 1st, 24th, 28th, 29th; Grainpian Hills, 1st, 25th, 28th, 29th, 30th; Catawissa, 25th, 28th, 29th, 30th; Meadville, 1st, 2d, 25th, 29th, 30th; Waynesburg, 2d; Huntingdon, 28th, 29th; Petersburg, 2d, 25th, 28th; Indiana, 28th, 29th, 30th; Lancaster 25th, 30th; New Castle, 28th, 29th; Myerstown, 19th, 25th, 29th, 30th; Coopersburg, 25th; Wilkes-Barre, 29th, 30th; Nisbet, 25th, 28th; Greenville, 24th, 25th, 29th; Bethlehem, 25th, 29th; Philadelphia, 25th, 29th; Girardville, 21st, 23d, 24th, 25th, 26th, 28th, 29th, 30th; Selins Grove, 25th, 28th, 29th; Somerset, 1st, 24th, 28th, 30th; Wells-

COUNTY.

Adams,[1]
Allegheny,[1]
Bedford,
Blair,[2]
Blair,
Blair,
Blair,
Bradford,
Bradford,
Bucks,
Bucks,
Cambria,[1]
Cameron,
Carbon,[1]
Centre,

Centre,
Chester,
Chester,
Chester,[1]
Chester,
Chester,
Clarion,
Clarion,

Clearfield,
Clinton,
Columbia,
Crawford,
Cumberland,
Dauphin,[1]
Delaware,

Erie,[1]
Fayette,
Franklin,[1]

Fulton,
Greene,
Huntingdon,[1]

Huntingdon,
Indiana,

Lancaster,
Lawrence,
Lebanon,
Lebanon,

Lehigh,
Lehigh,[1]
Luzerne,

Luzerne,[1]
Lycoming,[1]
Mercer,[1]

Mifflin,
Montgomery,
Northampton,
Philadelphia,[1]

Schuylkill,
Snyder,
Somerset,
Sullivan,
Tioga,
Union,[1]
Warren,
Washington,
Wayne,
Wayne,
Westmoreland,
Wyoming,[1]
York,[1]

[1] Observatio

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Serv

County.	Station.	Elevation above Sea Level (feet).	Barometer Reduced to Sea Level.			Temperature.												Relative Humidity.		Precip.
							Maximum.		Minimum.				Daily Range.							
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.		Dew Point.	Total Inches.
Adams,[1]	Gettysburg,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Allegheny,[1]	Pittsburgh,	847	30·130	30·390	29·880	64·6	89·0	8	40·0	28	73·5	55·7	17·8	31·0	2	5·0	9	73·0	55·0	4·24
Bedford,	Charlesville,	1,300	...	...	...	60·6	84·0	3, 7	29·0	29	72·6	50·4	22·2	39·0	1	6·0	11	84·0	53·6	4·05
Blair,[2]	Altoona,	1,181	...	...	...	64·0	84·0	5	35·0	29	72·4	55·6	16·8	27·0	14	8·0	12	69·8	54·0	3·98
Blair,	Blue Knob,	2,500	...	...	...	59·3	...	...	...	...	...	...	...	...	...	...	...	...	...	6·60
Blair,	Hollidaysburg,	947	...	...	...	62·0	89·0	7	29·0	29	75·0	49·0	26·0	43·0	1	10·0	11	81·5	58·0	5·18
Blair,	Tipton,	915	...	...	...	62·2	90·0	3	35·0	28, 29	74·1	54·3	19·8	39·0	3	4·0	11	...	...	3·67
Bradford,	Wysox,	718	30·154	30·432	29·866	59·4	85·0	5, 7	31·0	28	69·7	49·6	20·1	35·5	4	5·0	10	81·0	55·1	4·37
Bradford,	Le Roy,	1,400	...	...	...	61·1	84·0	4	32·0	25	68·5	53·2	15·3	28·0	25	4·0	9	...	...	5·45
Bucks,	Forks of Neshaminy,	...	...	...	...	64·5	...	...	...	...	...	...	...	...	...	...	...	...	...	3·05
Bucks,	Quakertown,	536	30·130	30·380	29·870	62·0	87·0	5	33·0	25	74·1	51·9	22·2	35·7	30	7·0	11	81·8	57·1	4·82
Cambria,[1]	Johnstown,	1,184	30·163	30·419	29·910	63·5	84·0	7, 8	36·0	28, 29	74·3	52·7	21·6	33·0	14	9·0	11	86·3	56·3	5·85
Cameron,	Emporium,	1,030	...	...	...	60·0	84·0	7	32·0	26, 29	72·5	49·3	23·2	40·0	30	8·0	10	...	...	7·91
Carbon,[1]	Mauch Chunk (29 days),	550	...	...	...	62·4	87·0	5	31·0	28	73·3	51·6	21·7	38·5	30	4·0	11	...	...	4·64
Centre,	State College—Agricultural Experiment Station,	1,191	30·097	30·384	29·797	60·6	86·0	7	32·0	25	70·7	50·9	19·8	33·0	2	7·0	8	79·7	53·8	2·29
Centre,	Phillipsburg,	1,390	...	...	...	59·5	89·0	7	27·0	29	72·7	46·3	26·4	45·0	2	9·0	10	...	...	5·19
Chester,	West Chester,	455	30·118	30·366	29·885	64·3	87·0	5	41·0	25, 29	73·7	56·6	17·1	26·0	19	4·0	11	86·0	56·5	4·07
Chester,	Coatesville,	380	...	...	...	62·5	91·0	5	35·0	25	76·5	51·4	25·1	36·0	19	5·0	11	...	...	3·36
Chester,[1]	Kennett Square,	475	...	...	...	63·4	...	...	...	...	...	...	...	...	...	...	...	...	...	5·02
Chester,	Phœnixville,	...	30·144	30·392	29·912	65·4	88·0	5	36·0	25	74·2	56·7	17·5	30·5	25	4·5	11	84·0	59·0	3·09
Chester,	Westtown (29 days),	350	30·130	30·367	29·883	64·6	85·0	5	39·0	25	73·0	56·5	16·5	30·0	22	5·0	11	...	...	3·60
Clarion,	Rimersburg,	1,500	...	...	...	61·0	82·0	8	34·0	29	69·3	53·6	15·7	30·0	2	2·0	20	...	...	...
Clarion,	Clarion—State Normal School,	1,530	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Clearfield,	Grampian Hills,	1,450	...	...	...	59·6	84·0	2, 5, 7	34·0	1, 28, 29	70·6	51·1	19·5	44·0	2	2·0	10	...	...	5·87
Clinton,	Lock Haven,	560	...	...	...	62·1	90·0	7	33·0	28	72·8	54·8	18·0	38·0	2	6·0	11	...	...	3·87
Columbia,	Catawissa,	491	...	...	...	62·0	85·0	5	36·0	25, 29	70·5	54·0	16·5	29·0	3	5·5	14	...	...	2·81
Crawford,	Meadville,	1,320	30·055	30·370	29·730	57·9	84·0	7, 8	35·0	29	68·5	47·3	21·2	...	...	...	...	86·4	51·3	5·82
Cumberland,	Carlisle (29 days),	480	...	...	...	65·4	91·0	5	32·0	29	77·4	53·9	23·5	37·0	1	2·0	14	88·5	61·0	4·12
Dauphin,[1]	Harrisburg,	361	30·150	30·383	29·889	63·6	86·0	7	42·0	29	72·8	55·7	17·1	30·0	19	4·0	11	77·8	56·0	2·89
Delaware,	Swarthmore—Swarthmore College,	190	30·122	30·294	29·880	64·3	86·0	5	43·0	26	74·0	56·5	17·5	27·7	19	5·7	11	85·0	60·0	2·62
Erie,[1]	Erie,	681	30·110	30·390	29·800	61·0	87·0	7	39·0	29	68·0	54·0	14·0	23·0	3	5·0	27	79·0	53·0	5·16
Fayette,	Uniontown,	1,000	30·076	30·261	29·734	66·7	87·0	8	41·0	28, 29	75·4	56·6	18·8	34·0	2	6·0	27	...	...	6·73
Franklin,[1]	Chambersburg—Wilson Female College,	618	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Fulton,	McConnellsburg,	875	...	...	...	63·1	91·0	7	35·0	29	75·6	52·9	22·7	37·0	1	8·0	15	80·0	56·2	2·62
Greene,	Waynesburg,	750	...	...	...	56·4	84·0	8	31·0	28	65·7	48·3	17·4	34·0	1	7·0	9	...	...	5·90
Huntingdon,[1]	Huntingdon—The Normal College,	650	...	...	...	62·4	88·0	5	31·0	29	76·9	48·0	28·9	49·0	20	19·0	9	...	...	3·55
Huntingdon,	Petersburg,	700	...	...	...	63·5	90·0	2	33·0	28	77·1	53·5	23·6	44·0	2	4·0	10	...	...	2·35
Indiana,	Indiana—State Normal School,	1,350	30·197	30·415	29·996	61·2	84·0	7, 8	32·0	28	72·3	48·7	23·6	34·0	2	9·0	20	84·4	56·7	8·10
Lancaster,	Lancaster (17 days),	411	30·144	30·320	29·972	59·1	79·0	14, 19	30·0	24	64·0	41·4	22·6	34·5	19	17·5	26	87·9	51·8	1·24
Lawrence,	New Castle,	932	...	...	...	62·9	90·0	8	28·0	28	73·4	48·5	24·9	44·0	2	7·0	20	...	...	7·48
Lebanon,	Myerstown,	474	30·087	30·260	29·891	62·3	90·0	5	33·0	25	74·5	52·2	22·3	36·5	30	4·0	11	79·8	59·7	5·15
Lebanon,	Annville—Lebanon Valley College,	339	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Lehigh,	Coopersburg,	520	...	...	...	62·9	87·0	5	38·0	25, 30	73·3	55·0	18·3	30·0	30	4·0	11	...	...	4·18
Lehigh,[1]	Lynnport,	350	...	...	...	63·1	87·0	4, 5	30·0	25	74·3	51·9	22·4	45·0	4	5·0	14	...	...	5·20
Luzerne,	Drifton—Drifton Hospital,	1,655	...	...	...	58·7	81·0	5	35·0	29	68·9	51·1	17·8	29·0	2	7·0	11	...	...	3·55
Luzerne,[1]	Wilkes-Barre,	575	...	...	...	62·2	88·0	5	32·0	30	74·5	50·0	24·5	38·0	30	11·0	9	...	...	2·42
Lycoming,[1]	Nisbet,	550	...	...	...	60·6	...	...	...	...	...	...	...	...	...	...	...	...	...	3·90
Mercer,[1]	Greenville—Thiel College,	1,000	30·089	30·325	29·762	60·9	87·0	7	35·0	29	72·1	49·8	22·3	40·2	2	3·8	10	73·9	54·6	6·19
Mifflin,	Lewistown,	500	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Montgomery,	Pottstown,	150	...	...	...	66·0	89·0	5	39·0	25	76·0	57·2	19·0	31·0	2	2·0	11	84·0	60·0	4·01
Northampton,	Bethlehem,	360	...	...	...	65·0	86·0	5	44·0	25	73·6	54·5	19·1	34·0	30	8·0	13	83·0	59·0	3·51
Philadelphia,[1]	Philadelphia—Signal Office,	117	30·151	30·380	29·880	67·2	88·0	5	45·0	25	74·8	59·6	15·2	25·0	25	4·0	11	78·9	58·0	2·31
Schuylkill,	Girardville,	1,000	30·102	30·303	29·910	61·4	84·0	5	36·0	25, 26	70·8	51·4	19·4	29·0	30	7·0	11	...	...	4·51
Snyder,	Selins Grove,	445	...	...	...	62·2	87·0	7	37·0	29	71·6	54·2	17·4	30·0	3	1·0	14	85·5	58·8	3·13
Somerset,	Somerset,	2,250	...	...	...	59·6	83·0	4	32·0	28	72·4	49·5	22·9	40·0	1	7·0	30	89·2	58·0	7·84
Sullivan,	Eagles Mere,	2,000	30·156	30·395	29·908	59·6	79·0	3	34·0	28	64·6	50·9	13·7	24·0	1	3·0	13	81·4	53·1	7·11
Tioga,	Wellsboro,	1,327	30·103	30·431	29·820	56·4	88·0	7	30·0	29, 30	64·5	48·6	15·9	38·0	4	6·0	20	68·4	54·2	4·39
Union,[1]	Lewisburg,	450	...	...	...	63·2	88·0	5	34·0	25	74·3	52·2	22·1	32·0	25	10·0	11	...	...	3·70
Warren,	Columbus,	1,410	...	...	...	59·8	90·0	7	30·0	29, 30	71·4	48·3	23·1	46·0	30	1·0	27	69·7	47·7	7·10
Washington,	Canonsburg,	950	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Wayne,	Dyberry,	1,100	...	...	...	56·4	82·0	4, 7	25·0	25	68·4	46·9	21·5	41·0	30	2·0	14	...	...	4·40
Wayne,	Honesdale,	1,000	...	...	...	59·8	82·0	5	32·0	25, 29	68·4	51·1	17·3	34·0	30	3·0	10	70·9	56·4	4·55
Westmoreland,	Ligonier,	1,750	...	...	...	64·0	87·0	8	30·0	28, 29	74·7	49·4	25·3	43·0	2	9·0	20	85·0	58·0	8·54
Wyoming,[1]	South Eaton	660	...	...	...	57·5	82·0	4, 5	35·0	25, 29	69·7	51·6	18·1	29·0	30	4·0	11	...	...	2·05
York,[1]	York,	385	30·100	30·324	29·925	67·3	88·0	5, 7	34·0	25	75·2	59·4	15·8	38·0	5	10·5	11	82·5	59·0	4·55

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

Voluntary Observers of the Pennsylvania State Weather Service for September, 189

Temperature.									Relative Humidity.	Dew Point.	Precipitation.		Number of Days.		
Minimum.		Mean of Maximum.	Mean of Minimum.	Daily Range.											
Lowest.	Date.			Mean.	Greatest.	Date.	Least.	Date.			Total Inches.	Number of Days Rainfall.	Clear.	Fair.	Cloudy.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
40·0	28	73·5	55·7	17·8	31·0	2	5·0	9	75·0	55·0	4·24	14	7	14	9
29·0	29	72·6	50·4	22·2	39·0	1	6·0	11	84·0	53·6	4·05	11	10	11	9
35·0	29	72·4	55·6	16·8	27·0	14	8·0	12	69·8	54·0	3·98	14	...	...	...
...	...	...	...	...	...	...	...	...	...	...	6·60	13	8	10	12
29·0	29	75·0	49·0	26·0	43·0	1	10·0	11	85·5	58·0	5·18	13	10	10	10
33·0	28, 29	74·1	54·3	19·8	39·0	3	4·0	11	...	...	3·67	10	8	11	11
31·0	28	69·7	49·6	20·1	35·5	4	5·0	10	85·0	55·1	4·37	10	12	3	15
32·0	25	68·5	53·2	15·3	28·0	25	4·0	9	...	...	5·45	11	11	7	12
...	...	...	...	...	...	...	...	...	...	...	3·05	12	14	8	8
33·0	25	74·1	51·9	22·2	35·7	30	7·0	11	83·8	57·1	4·82	10	11	10	9
36·0	28, 29	74·3	52·7	21·6	33·0	14	9·0	11	88·3	56·3	5·85	14	9	10	11
32·0	26, 29	72·5	49·3	23·2	40·0	30	8·0	10	...	...	7·01	12	12	7	11
31·0	28	73·3	51·6	21·7	38·5	30	4·0	11	...	...	4·64	11	11	10	9
32·0	25	70·7	50·9	19·8	33·0	2	7·0	8	79·7	53·8	2·29	13	8	12	10
27·0	29	72·7	46·3	26·4	45·0	2	9·0	10	...	...	5·19	12	10	8	12
41·0	25, 29	73·7	56·6	17·1	26·0	19	4·0	11	78·0	56·5	4·07	12	13	8	9
35·0	25	76·5	51·4	25·1	36·0	19	5·0	11	...	...	3·36	9	12	10	8
...	...	...	...	...	...	...	...	...	...	...	5·02	11	11	8	11
36·0	25	74·2	56·7	17·5	30·5	25	4·5	11	84·0	59·0	3·[illegible]	9	7	9	14
39·0	25	73·0	56·5	16·5	30·0	22	5·0	11	...	...	3·60	9	11	6	12
34·0	29	69·3	53·6	15·7	30·0	2	2·0	20	...	...	...	14	9	13	8
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
34·0	1, 28, 29	70·6	51·1	19·5	44·0	2	2·0	10	...	...	5·87	13	4	16	10
33·0	28	72·8	54·8	18·0	38·0	2	6·0	11	...	...	3·87	15	11	10	9
36·0	25, 29	70·5	54·0	16·5	29·0	3	5·5	14	...	...	2·81	9	...	...	...
35·0	29	68·5	47·3	21·2	...	...	...	...	82·4	51·3	5·82	10	11	9	10
32·0	29	77·4	53·9	23·5	37·0	1	2·0	14	88·5	61·0	4·19	11	10	12	7
42·0	29	72·8	55·7	17·1	30·0	19	4·0	11	77·8	56·0	2·89	11	10	9	10
43·0	26	74·0	56·5	17·5	27·7	19	5·7	11	85·0	60·0	2·62	9	1	11	18
39·0	29	68·0	54·0	14·0	23·0	3	5·0	27	79·0	53·0	5·16	13	8	11	11
41·0	28, 29	75·4	56·6	18·8	34·0	2	6·0	27	...	...	6·73	10	16	11	3
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
35·0	29	75·6	52·9	22·7	37·0	1	8·0	15	80·0	56·2	2·62	7	9	13	8
31·0	28	65·7	48·3	17·4	34·0	1	7·0	9	...	...	5·90	9	9	10	11
31·0	29	76·9	48·0	28·9	49·0	20	19·0	9	...	...	3·55	5	19	4	7
33·0	28	77·1	53·5	23·6	44·0	2	4·0	10	...	...	2·35	9	12	11	7
32·0	28	72·3	48·7	23·6	34·0	2	9·0	20	84·4	56·7	8·10	13	8	12	10
30·0	24	64·0	41·4	22·6	34·5	19	17·5	26	87·9	51·8	1·24	4	4	9	9
28·0	28	73·4	48·5	24·9	44·0	2	7·0	20	...	...	7·48	12	11	10	9
33·0	25	74·5	52·2	22·3	36·5	30	4·0	11	89·8	59·7	5·15	8	9	3	18
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
38·0	25, 30	73·3	55·0	18·3	30·0	30	4·0	11	...	...	4·18	9	10	7	13
30·0	25	74·3	51·9	22·4	45·0	4	5·0	14	...	...	5·20	...	4	13	13
35·0	29	68·9	51·1	17·8	29·0	2	7·0	11	...	...	3·55	7	...	...	...
32·0	30	74·3	50·0	24·5	38·0	30	11·0	9	...	...	2·42	8	13	2	15
...	...	...	...	...	...	...	...	...	...	...	3·90	7	...	...	...
35·0	29	72·1	49·8	22·3	40·2	2	3·8	10	93·9	54·6	6·19	13	7	10	13
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
39·0	25	76·0	57·0	19·0	31·0	2	2·0	11	84·0	60·0	4·01	8	14	9	7
34·0	25	73·6	54·5	19·1	34·0	30	8·0	13	83·0	59·0	3·51	7	15	5	10
45·0	25	74·8	59·6	15·2	25·0	25	4·0	11	78·0	58·0	2·31	11	9	7	14
36·0	25, 26	70·8	51·4	19·4	29·0	30	7·0	11	...	...	4·51	9	16	3	11
37·0	29	71·6	54·2	17·4	30·0	3	1·0	14	85·5	58·8	3·13	7	7	14	9
32·0	28	72·4	49·5	22·9	40·0	1	7·0	30	89·2	58·0	7·84	10	9	8	13
34·0	28	64·6	50·9	13·7	24·0	1	3·0	13	81·4	53·1	7·11	10	12	5	13
30·0	29, 30	64·5	48·6	15·9	38·0	4	6·0	20	68·4	34·2	4·39	11	4	11	15
24·0	25	74·3	52·2	22·1	32·0	25	10·0	11	...	...	3·70	10	8	15	7
30·0	29, 30	71·4	48·3	23·1	46·0	30	1·0	27	69·7	47·7	7·10	12	9	10	11
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
25·0	25	68·4	46·9	21·5	41·0	30	2·0	14	...	...	4·40	10	12	4	14
32·0	25, 29	68·4	51·1	17·3	34·0	30	3·0	10	70·9	56·4	4·55	13	...	...	...
30·0	28, 29	74·7	49·4	25·3	43·0	2	9·0	20	85·0	58·0	8·54	13	15	8	7
35·0	25, 29	69·7	51·6	18·1	29·0	30	4·0	11	...	...	2·05	9	12	5	13
34·0	25	75·2	59·4	15·8	38·0	5	10·5	11	82·5	59·0	4·55	9	20	3	7

T.

Number of Days.		Wind.			Observers.
		Prevailing Direction.			
Fair.	Cloudy.	7 A. M.	2 P. M.	9 P. M.	
...	...	...	...	...	Prof. E. S. Breidenbaugh.
14	9	S	S	S	Oscar D. Stewart, Sgt. Sig. Corps.
11	9	N	SW	N	Miss E. A. G. Apple.
...	...	...	...	...	Dr. Charles B. Dudley.
10	12	SW	NW	NW	A. H. Boyle.
10	10	W	W	SW	Prof. J. A. Stewart.
11	11	W	W	W	Miss Cora J. Wilson.
3	15	SE	W	SE	Charles Beecher.
7	12	SW	SW	SW	Geo. W. T. Warburton.
8	8	N	N	N	J. C. Hilsman.
10	9	SW	SW	SW	J. L. Heacock.
10	11	S	S	S	E. C. Lorentz.
7	11	NW	NW	NW	T. B. Lloyd.
10	9	NW	NW	NW	John J. Boyd.
13	10	N	SW	SW	Prof. Wm. Frear.
8	12	SW	SW	SW	Geo. H. Dunkle.
8	9	NW	S	S	Jesse C. Green, D.D.S.
10	8	W	W	S	W. T. Gordon.
8	11	N	N	N	Benj. P. Kirk.
9	14	NW	...	SE	Knowles Croskey.
6	12	W	W	E	Prof. Wm. F. Wickersham.
13	8	N	W	W	Rev. W. W. Deatrick, A.M.
...	...	...	...	...	C. M. Thomas, B.S.
16	10	E	SW	E	Nathan Moore.
10	9	W	W	W	Prof. John A. Robb.
...	...	...	...	...	Robert M. Graham.
9	10	S	S	S	J. & B. H. Metcalf.
12	7	S	S	W	J. E. Pague.
9	10	E	E	E	Frank Ridgway, Sgt. Sig. Corps.
11	18	S	SW	NW	Prof. Susan J. Cunningham.
11	11	S	S	S	Peter Wood, Sgt. Sig. Corps.
11	3	SW	SW	SW	Wm. Hunt.
...	...	...	...	...	Miss Mary A. Ricker.
13	8	...	...	...	Thomas F. Sloan.
10	11	...	...	...	Capt. W. C. Kimber.
4	7	W	W	W	Prof. W. J. Swigart.
11	7	W	W	W	J. E. Rooney.
12	10	N	NW	NW	Prof. S C. Schmucker.
9	9	NW	NW	NW	C. N. Heller.
10	9	S	S	E	Wm. T. Butz.
3	18	W	W	W	Wm. H. Kline.
...	...	...	...	...	Geo. W. Bowman, A.M., Ph.D.
7	13	NE	SE	NE	M. H. Boye.
13	13	...	...	...	John C. Wuchter.
...	...	...	...	...	H. D. Miller, M.D.
2	15	E	E	E	A. W. Betterly.
...	...	...	...	...	John S. Gibson, P. M.
10	13	S	S	S	Prof. S. H. Miller.
...	...	...	...	...	Cuibertson & Lantz.
9	7	NW	SW	SW	Charles Moore, D.D.S.
5	10	W	W	W	Lerch & Rice.
7	14	NE	NE	NE	Luther M. Dey, Sgt. Sig. Corps.
3	11	NW	W	NW	E. C. Wagner.
14	9	SE	SE	SE	J. M. Boyer,
8	13	NW	NW	NW	W. M. Schrock.
5	13	SW	SW	SW	E. S. Chase.
11	15	S	S	S	H. D. Deming.
15	7	SW	SW	SW	F. O. Whitman.
10	11	SW	SW	SW	Wm. Loveland.
...	...	...	...	...	A. L. Runion, M.D.
4	14	W	NW	W	Theodore Day.
...	...	...	...	...	John Torrey.
8	7	...	...	...	J. T. Ambrose.
5	13	NW	NW	NW	Benj. M. Hall.
3	7	NW	NW	NW	Mrs. L. H. Grenewald.

T. F. TOWNSEND, *Sergeant Signal Corps, Assistant.*

boro, 1st, 2d, 21st, 25th, 28th, 29th, 30th; Lewisburg, 30th; Columbus, 1st, 2d, 25th, 29th, 30th; Dyberry, 25th, 28th, 29th, 30th; Honesdale, 25th, 29th, 30th; Ligonier, 28th, 29th; South Eaton, 25th, 28th, 29th; York, 25th, 29th, 30th; Eagles Mere, 25th, 28th, 30th.

Coronæ.—Charlesville, 23d; Dyberry, 21st, 25th; Eagles Mere, 25th.

Solar Halos.—Le Roy, 14th, 22d, 25th; Meadville, 5th, 14th, 18th; Eagles Mere, 14th, 24th, 25th.

Lunar Halos.—Charlesville, 18th; Hollidaysburg, 25th; Phœnixville, 23d, 28th; Meadville, 27th; Carlisle, 28th; Lancaster, 22d, 23d; Somerset, 29th, 30th; York, 25th.

Meteors.—Charlesville, 23d.

Earthquake.—Phœnixville, 4th.

WEATHER FORECASTS.

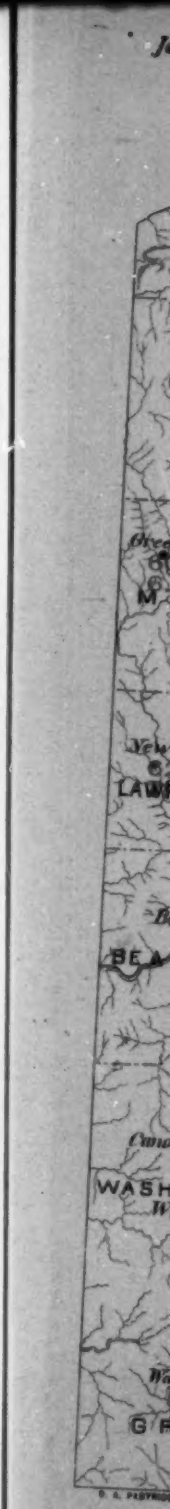
Percentage of local verifications of weather and temperature signals as reported by displaymen for September, 1890:

Weather, 88 per cent.
Temperature, 90 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
D. G. Hurley,	Altoona.

Displayman.	*Station.*
J. E. Forsythe,	Butler.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
Raftsman's Journal,	Clearfield.
R. C. Schmidt & Co.,	Belle Vernon.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
C. A. Hinsdell,	Scranton.
H. M. Kaisinger,	Hartsville.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.
Wister Heberton & Co.,	Germantown.
Charles M. Mullen,	Bedford.
E. W. Merrill,	North East.
A. Simon's Sons,	Lock Haven.
Frank Ridgway,	Harrisburg.
G. W. Yost,	Collegeville.
A. C. Tryon,	Spartansburg.
A. H. Gerbench,	Annville.
Knowles Croskey,	Phoenixville.
Powell Bros.,	Shadeland.
Lincoln E. Rowley,	Athens.



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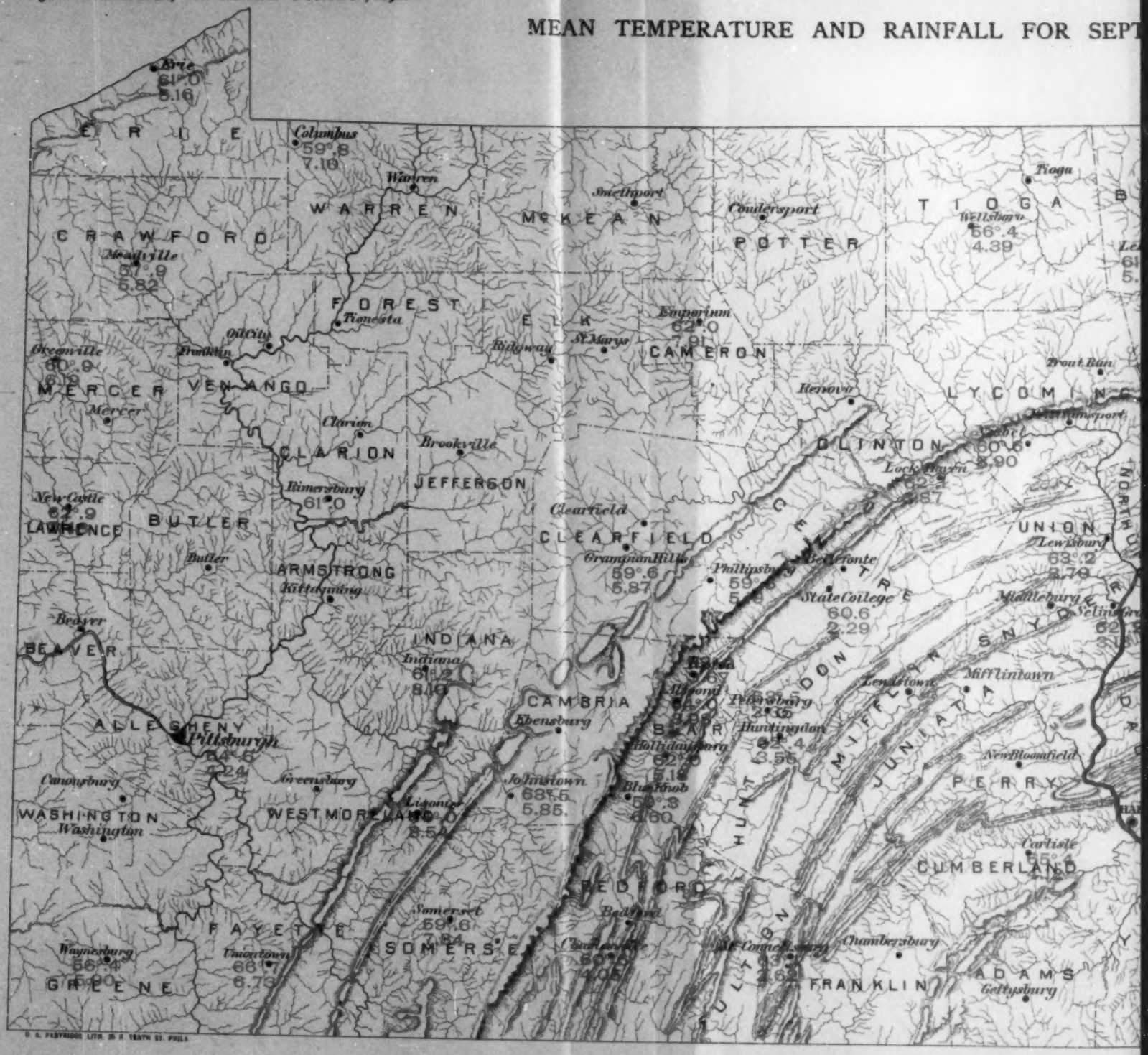
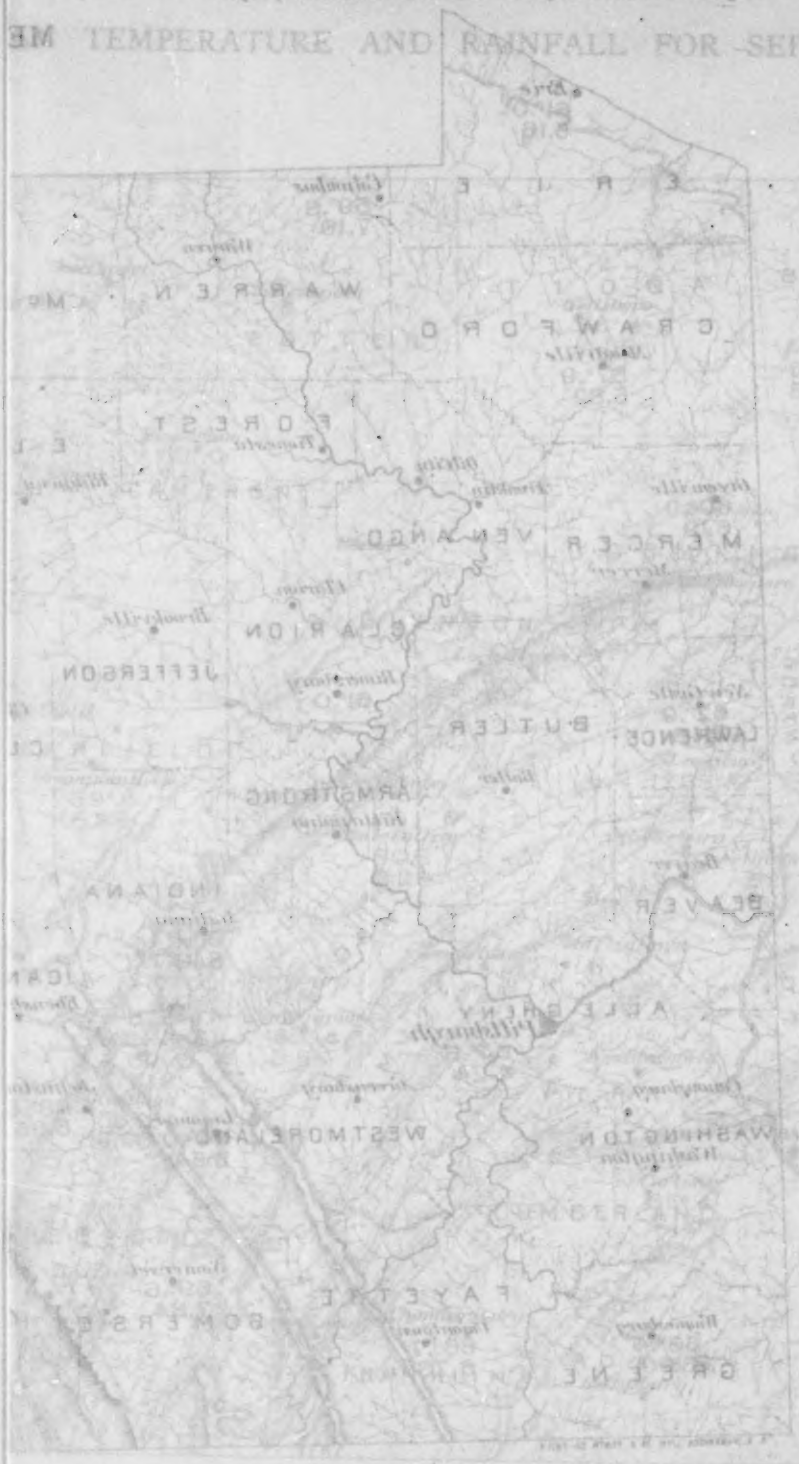


RATURE AND RAINFALL FOR SEPTEMBER, 1890.

State Weather Service.

ME TEMPERATURE AND RAINFALL FOR SEPT



PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR OCTOBER, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, October 31, 1890.

TEMPERATURE.

The mean temperature of 59 stations for October, 1890, was 50°·9, which is about 1°·0 below the normal, and 3°·7 above the corresponding month of 1889.

The mean of the daily maximum and minimum temperatures 58°·7 and 43°·2 give an average daily range of 15°·5, and a monthly mean of 50°·9.

Highest monthly mean, 56°·4 at Uniontown.

Lowest monthly mean, 44°·8 at Eagles Mere.

Highest temperature recorded during the month, 81°·0 on the 15th at Selins Grove.

Lowest temperature, 21°·0 on the 31st at Dyberry.

Greatest local monthly range, 55° at Wilkes-Barre.

Least local monthly range, 36° at Altoona.

Greatest daily range, 43° at Huntingdon on the 9th.

Least daily range, 1°·0 at Waynesburg on the 21st.

From January 1, 1890, to October 31, 1890, the excess in temperature at Philadelphia was 656°, at Erie 113° and at Pittsburgh 652°.

The coldest period of the month was on the 31st.

BAROMETER.

The mean pressure for the month, 29·92, is about ·15 below the normal. At the U. S. Signal Service Stations, the highest observed was 30·37 at Philadelphia on the 9th, and the lowest 29·28 at Erie on the 29th.

PRECIPITATION.

The average rainfall 5·87 inches for the month, is an excess of 2·50 inches.

The largest monthly totals in inches were Eagles Mere, 8·41; Uniontown, 7·41; Dyberry, 7·39; Lancaster, 7·34; Quakertown, 7·25; Columbus, 7·25; Somerset, 7·12.

The least were Mauch Chunk, 4·03; Altoona, 4·12; Wysox, 4·24; Wellsboro, 4·69; Meadville, 4·75; Philadelphia, 4·82; Wilkes-Barre, 4·85.

With the exception of the 9th, precipitation fell on every day on some sections of the State.

The following totals in snowfall were reported: Somerset, 5·25; Eagles Mere, 4·15; Grampian Hills, 3·50; Columbus, 3·00; Meadville, 2·25; Rimersburg, 1·75 and Greenville, 1·00 inches. The snowfalls occurred on the 27th, 28th, 29th, 30th and 31st.

WIND AND WEATHER.

The prevailing wind was from the West. The weather was nearly normal in temperature, and above in precipitation and humidity.

Average number: Rainy days, 15; clear days, 6; fair days, 8; cloudy days, 17.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Blue Knob, 1st, 18th; Coatesville, 29th; Kennett Square, 29th; Westtown, 29th; Meadville, 14th, 18th; Carlisle, 3d; Swarthmore, 29th; Philadelphia, 30th; Selins Grove, 2d; Lewisburg, 2d; Columbus, 6th.

Hail.—Blue Knob, 26th; Wysox, 30th; Coatesville, 29th; Wilkes-Barre, 14th; Greenville, 14th; Philadelphia, 30th; Eagles Mere, 19th; Dyberry, 23d.

Snow.—Charlesville, 30th, 31st; Blue Knob, 27th, 28th, 29th, 30th, 31st; Hollidaysburg, 30th; Le Roy, 27th, 28th; Johnstown, 27th, 28th, 29th, 30th, 31st; Emporium, 27th, 30th, 31st; Rimersburg, 29th, 31st; Meadville, 27th, 30th, 31st; Grampian Hills, 28th, 29th, 30th, 31st; Chambersburg, 29th; Waynesburg, 30th, 31st; Indiana, 14th, 29th, 30th; New Castle, 29th; Wilkes-Barre, 29th; Greenville, 26th, 27th, 29th, 30th, 31st; Girardville, 28th, 29th; Somerset, 28th, 29th, 30th; Eagles Mere, 27th, 28th, 29th, 30th; Columbus, 30th, 31st; Dyberry, 28th, 30th; Ligonier, 31st.

Frost.—Pittsburgh, 30th, 31st; Charlesville, 22d; Altoona, 20th, 27th, 30th, 31st; Blue Knob, 9th, 15th, 18th, 22d, 26th; Hollidaysburg, 31st; Tipton, 22d, 31st; Wysox, 30th, 31st; Le Roy, 22d, 31st; Quakertown, 9th, 21st, 22d, 30th, 31st; State College, 22d, 31st; Phœnixville, 18th, 22d, 31st; Coatesville, 18th, 22d, 26th, 28th, 30th, 31st; Westtown, 31st; Rimersburg, 21st, 22d, 28th; Grampian Hills, 15th, 18th; Lock Haven, 30th, 31st; Meadville, 15th, 18th, 22d; Carlisle, 22d; Harrisburg, 22d; Erie, 18th, 22d; Chambersburg, 29th; Huntingdon, 31st; Indiana, 8th, 26th; Lancaster, 22d, 31st; New Castle, 22d, 31st; Myerstown, 1st, 9th, 15th, 18th, 22d, 31st; Coopersburg, 9th, 22d, 30th; Wilkes-Barre, 10th, 13th, 18th, 31st; Nisbet, 18th, 20th, 21st; Greenville, 18th, 22d; Bethlehem, 21st, 30th, 31st; Philadelphia, 22d, 31st; Girardville, 8th, 9th, 10th, 13th, 15th, 16th, 19th, 20th, 21st, 22d, 23d, 24th, 25th, 26th, 27th, 28th, 29th, 30th, 31st; Selins Grove, 9th, 15th, 18th, 22d, 31st; Somerset, 22d; Eagles Mere, 8th, 9th, 18th, 21st, 22d; Wellsboro, 9th, 10th, 15th, 18th, 22d, 27th, 28th, 31st; Lewisburg, 1st, 22d; Columbus, 18th, 22d, 28th, 30th, 31st; Dyberry, 9th, 10th, 12th, 13th, 16th, 22d, 27th, 28th, 29th, 30th, 31st; Honesdale, 22d, 31st; Ligonier, 22d; South Eaton, 17th, 31st; York, 15th, 22d, 31st.

Sleet.—Blue Knob, 26th.

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weath

County.	Station.	Elevation above Sea Level (feet).	Barometer Reduced to Sea Level.			Temperature.													Relative Humidity.	Dew Point.
							Maximum.		Minimum.				Daily Range.							
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.		
Adams,[1]	Gettysburg,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	...
Allegheny,[1]	Pittsburgh,	847	29·950	30·290	29·310	54·2	78·0	13	35·0	31	61·0	47·5	13·5	25·0	13	5·0	23		75·8	44·8
Bedford,	Charlesville,	1,300	...	...	...	50·0	65·0	10	28·0	31	58·6	42·3	16·3	32·0	10	4·5	23		87·0	47·0
Blair,[2]	Altoona,	1,181	...	...	...	53·9	74·0	11	38·0	29, 31	60·8	46·9	13·9	25·0	9	6·0	25		71·5	44·5
Blair,	Blue Knob,	2,500	...	...	...	46·3	...	...	...	...	...	...	...	...	...	...	...		...	...
Blair,	Hollidaysburg,	947	...	...	...	50·7	77·0	5, 10	27·0	31	60·5	40·6	19·9	36·0	6	8·0	13		88·0	48·0
Blair,	Tipton,	915	...	...	...	51·4	79·0	1, 5	34·0	31	59·9	46·0	13·9	33·0	10	2·0	12		...	...
Bradford,	Wysox,	718	29·945	30·383	29·397	48·1	75·0	1	22·0	31	56·2	40·4	15·8	36·0	1	4·5	26		84·5	43·9
Bradford,	Le Roy,	1,400	...	...	...	48·7	70·0	1, 3, 10	29·0	31	54·0	43·6	10·4	24·0	9	2·0	20		...	...
Bucks,	Forks of Neshaminy,	...	...	...	...	52·4	...	...	...	...	...	...	...	...	...	...	...		...	...
Bucks,	Quakertown,	536	29·930	30·340	29·360	50·6	76·0	1	22·0	31	59·9	42·5	17·4	30·5	9	6·0	24		82·2	44·9
Cambria,[1]	Johnstown,	1,184	29·995	30·377	29·350	52·4	76·0	10	34·0	22, 31	60·4	44·5	15·9	31·0	9	5·0	23		90·2	47·0
Cameron,	Emporium,	1,030	...	...	...	51·2	75·0	4, 5	29·0	31	57·5	40·3	17·2	34·0	18	6·0	13		...	...
Carbon,[1]	Mauch Chunk (30 days),	550	...	...	...	52·5	75·0	1	23·0	31	60·7	44·3	16·4	37·0	22	4·0	7		...	...
Centre,	State College—Agricultural Experiment Station,	1,191	29·892	30·324	29·233	49·3	73·0	10	28·0	31	56·3	42·9	13·4	31·0	10	3·0	13		79·5	42·7
Centre,	Phillipsburg,	1,350	...	...	...	48·3	75·0	5	28·0	30	58·2	40·0	18·2	35·0	10	5·0	27		...	...
Chester,	West Chester,	455	29·903	30·303	29·275	52·5	74·0	4	32·0	31	59·7	47·0	12·7	23·0	10	4·0	2		76·0	45·0
Chester,	Coatesville,	380	...	...	...	51·9	77·0	1, 5, 10	25·0	31	62·7	43·9	18·8	35·0	18	5·0	23		...	...
Chester,[1]	Kennett Square,	275	...	...	...	50·9	...	...	...	...	...	...	...	...	...	...	...		...	...
Chester,	Phœnixville,	...	29·927	30·369	29·440	54·1	75·0	4	29·0	31	61·1	47·1	14·0	28·0	1	5·0	23		83·9	47·3
Chester,	Westtown,	350	29·957	30·361	29·402	53·6	73·0	4	29·0	31	60·0	47·7	12·3	24·0	1	5·0	12		...	...
Clarion,	Rimersburg,	1,500	...	...	...	49·4	74·0	5	*30·0	30, 31	55·1	44·1	11·0	22·0	15	2·0	23		...	...
Clarion,	Clarion—State Normal School (28 days),	1,530	...	...	...	48·8	73·0	10	29·0	28, 29	55·5	39·7	15·8	27·5	10	4·0	18		92·7	46·5
Clearfield,	Grampian Hills,	1,450	...	...	...	48·2	74·0	10	30·0	31	55·3	43·0	12·3	30·0	18	...	...		...	...
Clinton,	Lock Haven,	560	...	...	...	50·7	75·0	3, 4, 5	26·0	31	58·4	43·3	15·1	34·0	18	2·0	23		...	...
Columbia,	Catawissa,	491	...	...	...	51·0	72·0	1	29·0	31	57·3	45·0	12·3	26·0	10	5·0	25		...	...
Crawford,	Meadville,	1,320	29·899	30·300	29·250	48·7	71·0	9	32·0	22, 30	56·7	40·7	16·0	...	...	...	...		87·0	44·3
Cumberland,	Carlisle,	480	...	...	...	52·3	79·0	5	31·0	31	62·1	44·4	17·7	38·0	1	5·0	6		88·5	49·0
Dauphin,[1]	Harrisburg,	361	29·968	30·368	29·421	54·8	76·0	5	34·0	31	59·5	46·9	12·6	25·0	1	3·0	6		75·6	44·6
Delaware,	Swarthmore—Swarthmore College,	190	29·903	30·303	29·415	53·4	77·0	1	31·0	31	60·9	48·3	12·6	28·2	1	5·0	7		83·0	48·0
Erie,[1]	Erie,	681	29·900	30·280	29·280	51·0	73·0	9	32·0	30	57·0	46·0	11·0	24·0	18	4·0	12		82·0	45·0
Fayette,	Uniontown,	1,000	29·931	30·239	29·545	56·4	79·0	13	36·0	28, 29	64·0	48·8	15·2	29·0	18	6·0	29		...	...
Franklin,[1]	Chambersburg—Wilson Female College,	618	29·923	30·298	29·434	53·2	78·0	5	28·0	31	62·8	43·7	19·1	36·0	1	7·0	13		85·4	45·8
Fulton,	McConnellsburg,	875	...	...	...	52·5	78·0	5	32·0	31	61·4	44·2	17·2	32·0	18	6·0	23		81·6	50·7
Greene,	Waynesburg,	750	...	...	...	45·1	71·0	13	27·0	31	50·9	40·8	10·1	29·0	9	1·0	21		...	...
Huntingdon,[1]	Huntingdon—The Normal College,	650	...	...	...	50·6	78·0	11	24·0	31	61·3	39·9	21·4	43·0	9	5·0	13		...	...
Huntingdon,	Petersburg,	700	...	...	...	52·3	84·0	5	26·0	30	62·2	46·4	15·8	36·0	18	1·0	29		...	...
Indiana,	Indiana—State Normal School,	1,350	29·980	30·255	29·447	49·9	76·0	10	28·0	31	57·3	41·3	16·0	30·0	18	4·0	13		82·3	47·7
Lancaster,	Lancaster,	411	29·957	30·355	29·457	52·9	76·0	10	27·0	23	61·6	41·0	20·6	37·5	10	7·0	2		82·2	46·0
Lawrence,	New Castle,	932	...	...	...	52·7	76·0	8	28·0	22, 31	59·5	38·9	20·6	35·0	18	4·0	29		91·6	50·6
Lebanon,	Myerstown,	474	29·900	30·284	29·412	52·3	80·0	3	26·0	31	60·4	42·5	17·8	32·5	18	5·0	7		89·3	48·6
Lebanon,	Annville—Lebanon Valley College,	339	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	...
Lehigh,	Coopersburg,	520	...	...	...	53·3	74·0	1	30·0	31	59·5	43·5	14·0	26·0	1	5·0	2		...	...
Lehigh,[1]	Lynnport,	350	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	...
Luzerne,	Drifton—Drifton Hospital,	1,653	...	...	...	47·6	69·0	1	28·0	31	56·5	41·1	15·4	25·0	10	5·0	25		...	...
Luzerne,[1]	Wilkes-Barre,	575	...	...	...	48·2	79·0	1, 2	24·0	31	55·0	40·9	14·7	38·0	1	3·0	20		...	...
Lycoming,[1]	Nisbet,	550	...	...	...	50·7	...	...	...	...	...	...	...	...	...	...	...		...	...
Mercer,[1]	Greenville—Thiel College,	1,000	29·860	30·259	29·230	50·2	73·0	5	32·0	22	58·5	42·0	16·5	33·0	18	4·5	12		94·0	44·0
Mifflin,	Lewistown,	500	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	...
Montgomery,	Pottstown,	150	...	...	...	54·0	75·0	1, 3, 10	28·0	31	61·3	46·3	15·0	31·0	1	3·0	7		...	...
Northampton,	Bethlehem,	360	...	...	...	52·9	75·0	1	27·0	31	60·0	44·0	16·0	30·0	22	6·0	7		80·0	48·0
Philadelphia,[1]	Philadelphia—Signal Office,	117	29·930	30·370	29·470	55·5	79·0	1	36·0	31	61·5	49·5	12·0	24·0	1	5·0	24		73·9	45·4
Schuylkill,	Girardville,	1,000	29·885	30·283	29·353	50·2	70·0	1, 4, 10	31·0	30	56·4	42·7	13·7	32·0	10	5·0	20		...	...
Snyder,	Selins Grove,	445	...	...	...	51·7	81·0	15	...	...	64·8	38·6	26·2	...	...	...	...		92·7	45·8
Somerset,	Somerset,	2,250	...	...	...	49·0	75·0	5	28·0	22, 28	58·3	39·8	18·5	41·0	9	5·0	2		82·1	45·3
Sullivan,	Eagles Mere,	2,060	29·998	30·390	29·457	44·8	64·0	3, 5, 10	29·0	31	47·6	41·5	9·1	20·0	2	3·0	20		82·5	40·3
Tioga,	Wellsboro,	1,327	29·912	30·367	29·343	48·1	75·0	6	28·0	22	56·6	39·9	16·7	36·0	18	3·0	21		75·1	46·2
Union,[1]	Lewisburg,	450	...	...	...	52·3	75·0	3, 10	26·0	31	60·6	44·1	16·5	32·0	10	2·0	7		...	...
Warren,	Columbus (29 days),	1,410	...	...	...	48·6	76·0	1	28·0	18, 22	56·0	41·2	14·8	39·0	18	2·0	27		74·0	38·6
Washington,	Canonsburg,	950	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	...
Wayne,	Dyberry,	1,100	...	...	...	45·8	74·0	1	21·0	31	54·3	38·5	15·8	38·0	1	2·0	29		...	...
Wayne,	Honesdale,	1,000	...	...	...	48·2	69·0	1	25·0	31	55·2	41·2	14·0	30·0	10	4·0	7		70·7	44·3
Westmoreland,	Ligonier,	1,750	...	...	...	52·3	76·0	10	28·0	22	63·8	40·8	23·0	...	...	...	...		81·0	50·0
Wyoming,[1]	South Eaton,	660	...	...	...	49·8	75·0	1	26·0	31	56·5	41·2	15·3	32·0	1	3·0	14		...	...
York,[1]	York,	385	29·898	30·267	29·399	54·9	77·0	15	28·0	31	61·5	44·4	17·1	38·0	15	6·5	25		80·7	47·0

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

Voluntary Observers of the Pennsylvania State Weather Service for October, 189

Temperature.									Relative Humidity.	Dew Point.	Precipitation.			Number of Day		
inimum.		Mean of Maximum.	Mean of Minimum.	Daily Range.												
	Date.			Mean.	Greatest.	Date.	Least.	Date.			Total Inches.	Total Snowfall During Month.	Number of Days Rainfall.	Clear.	Fair.	
	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
	31	61·0	47·5	13·5	25·0	13	5·0	23	75·8	44·8	5·66	. . .	20	1	8	
	31	58·6	42·3	16·3	32·0	10	4·5	23	87·0	47·0	5·42	. . .	21	5	9	
	29, 31	60·3	46·9	13·9	25·0	9	6·0	25	71·5	44·5	4·12	. . .	16	. . .	. . .	
	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	18	4	9	
	31	60·5	40·6	19·9	36·0	6	8·0	13	88·0	48·0	5·02	. . .	19	8	3	
	31	59·9	46·0	13·9	33·0	10	2·0	12	. . .	. . .	5·72	. . .	23	9	8	
	31	56·2	40·4	15·8	36·0	1	4·5	26	84·5	43·9	4·24	. . .	18	7	2	
	31	54·0	43·6	10·4	24·0	9	2·0	20	. . .	. . .	5·37	. . .	16	6	5	
	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5·77	. . .	16	11	9	
	31	59·9	42·5	17·4	30·5	9	6·0	24	82·2	44·9	7·25	. . .	17	8	6	
	22, 31	60·4	44·5	15·9	31·0	9	5·0	23	90·2	47·0	5·26	. . .	23	4	9	
	31	57·5	40·3	17·2	34·0	18	6·0	13	. . .	. . .	5·30	. . .	13	6	6	
	31	60·7	44·3	16·4	37·0	22	4·0	7	. . .	. . .	4·03	. . .	12	9	6	
	31	56·3	42·9	13·4	31·0	10	3·0	13	79·5	42·7	5·24	. . .	21	2	10	
	30	58·2	40·0	18·2	35·0	10	5·0	27	. . .	. . .	5·31	. . .	17	. . .	. . .	
	31	59·7	47·0	12·7	23·0	10	4·0	2	76·0	45·0	6·28	. . .	19	9	8	
	31	62·7	43·9	18·8	35·0	18	5·0	23	. . .	. . .	6·34	. . .	16	12	8	
	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5·43	. . .	15	7	7	
	31	61·1	47·1	14·0	28·0	1	5·0	23	83·9	47·3	5·10	. . .	16	7	5	
	31	60·0	47·7	12·3	24·0	1	5·0	12	. . .	. . .	5·75	. . .	12	8	9	
	30, 31	55·1	44·1	11·0	22·0	15	2·0	23	. . .	. . .	. . .	1·75	21	5	12	
	28, 29	55·5	39·7	15·8	27·5	10	4·0	12	92·7	46·5	5·19	. . .	6	7	7	
	31	55·3	43·0	12·3	30·0	18	. . .	. . .	. . .	. . .	6·36	3·50	18	2	10	
	31	58·4	43·3	15·1	31·0	18	2·0	23	. . .	. . .	5·36	. . .	17	3	10	
	31	57·3	45·0	12·3	26·0	10	5·0	25	. . .	. . .	5·99	. . .	14	. . .	. . .	
	22, 30	56·7	42·7	16·0	. . .	. . .	. . .	. . .	87·0	44·3	4·75	2·25	20	4	8	
	31	62·1	44·4	17·7	38·0	1	5·0	6	88·5	49·0	5·72	. . .	15	5	11	
	31	59·5	46·9	12·6	25·0	1	3·0	6	75·0	44·6	6·40	. . .	15	8	6	
	31	60·9	48·3	12·6	28·2	1	5·0	7	83·0	48·0	6·16	. . .	12	1	12	
	30	57·0	46·0	11·0	24·0	18	4·0	12	82·0	45·0	6·13	. . .	22	4	6	
	28, 29	64·0	48·8	15·2	29·0	18	6·0	29	. . .	. . .	7·41	. . .	15	5	13	
	31	62·8	43·7	19·1	36·0	1	7·0	13	85·4	45·8	5·48	. . .	10	8	8	
	31	61·4	44·2	17·2	32·0	18	6·0	23	81·6	50·7	6·92	. . .	14	8	10	
	31	59·9	40·8	19·1	29·0	9	1·0	21	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
	31	61·3	39·9	21·4	41·0	9	5·0	13	. . .	. . .	5·04	. . .	13	12	8	
	30	62·2	46·4	15·8	36·0	18	1·0	29	. . .	. . .	5·59	. . .	18	5	16	
	31	57·3	41·3	16·0	30·0	18	4·0	23	82·3	47·7	5·31	. . .	17	4	9	
	23	61·6	41·0	20·6	37·5	10	7·0	2	82·2	46·0	7·34	. . .	15	3	10	
	22, 31	59·5	38·9	20·6	35·0	18	4·0	29	91·6	50·6	6·26	. . .	10	5	8	
	31	60·4	42·5	17·8	32·5	18	5·0	7	89·3	48·6	5·52	. . .	14	12	2	
	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
	31	59·5	45·5	14·0	26·0	1	5·0	2	. . .	. . .	6·04	. . .	16	8	6	
	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
	31	56·5	41·1	15·4	25·0	10	5·0	25	. . .	. . .	5·50	. . .	11	. . .	. . .	
	31	55·6	40·9	14·7	38·0	1	3·0	20	. . .	. . .	4·85	. . .	15	10	1	
	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	6·40	. . .	12	. . .	. . .	
	22	58·5	42·0	16·5	33·0	18	4·5	12	94·0	44·0	6·85	1·00	23	2	6	
	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
	31	61·3	46·3	15·0	31·0	1	3·0	7	. . .	. . .	6·10	. . .	11	12	5	
	31	60·0	44·0	16·0	30·0	22	6·0	7	80·0	48·0	6·17	. . .	10	5	3	
	31	61·5	49·5	12·0	24·0	1	5·0	24	73·9	45·4	4·82	. . .	15	8	3	
	30	56·4	42·7	13·7	32·0	10	5·0	20	. . .	. . .	6·24	. . .	14	11	4	
	. . .	64·8	38·6	26·2	. . .	. . .	. . .	. . .	93·7	45·8	6·97	. . .	12	3	12	
	22, 28	58·3	39·8	18·5	41·0	9	5·0	2	82·1	45·3	7·12	5·25	16	1	9	
	31	49·6	41·5	9·1	30·0	2	3·0	20	82·5	40·3	8·41	4·15	16	3	6	
	22	56·6	39·9	16·7	36·0	18	3·0	21	75·1	46·2	4·69	. . .	17	3	6	
	31	60·6	44·1	16·5	32·0	10	2·0	7	. . .	. . .	5·74	. . .	8	6	12	
	18, 22	56·0	41·2	14·8	39·0	18	2·0	27	74·0	38·6	7·25	3·00	. . .	. . .	9	
	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
	31	54·3	38·5	15·8	38·0	1	2·0	29	. . .	. . .	7·39	. . .	13	4	9	
	31	55·2	41·2	14·0	30·0	10	4·0	7	70·7	44·3	6·77	. . .	14	. . .	. . .	
	22	63·8	40·8	23·0	. . .	. . .	. . .	. . .	81·0	50·0	5·50	. . .	17	7	9	
	31	56·5	41·2	13·3	32·0	1	3·0	14	. . .	. . .	5·18	. . .	12	4	8	
	31	61·5	44·4	17·1	38·0	15	6·5	25	80·7	47·0	6·60	. . .	17	9	4	

Fair.	Cloudy.	Wind. Prevailing Direction. 7 A. M.	2 P. M.	9 P. M.	Observers.
..	....	....	....	....	Prof. E. S. Breidenbaugh.
8	22	W	W	W	Oscar D Stewart, Sgt. Sig. Corps.
9	17	SW	SW	SW	Miss E. A. G. Apple
..	....	....	....	....	Dr. Charles B. Dudley.
9	18	NW	NW	NW	A. H. Boyle.
3	20	W	W	W	Prof. J. A. Stewart.
8	14	W	W	W	Miss Cora J. Wilson.
2	22	SE	SE	SE	Charles Beecher.
5	20	SW	W	W	Geo. W. T. Warburton.
9	11	N	W	W	J. C. Hilsman.
6	17	NW	NW	NW	J. L. Heacock.
9	18	S	S	S	E. C. Lorentz.
6	19	NW	NW	W	T. B. Lloyd.
6	16	NW	NW	NW	John J. Boyd.
0	19	W	W	W	Prof. Wm. Frear.
..	....	SW	SW	SW	Geo. H. Dunkle.
8	14	NW	NW	NW	Jesse C. Green, D.D.S.
8	11	W	W	W	W. T. Gordon.
7	17	N	N	N	Benj. P. Kirk.
5	19	NW	NW	NW	Knowles Croskey.
9	14	W	W	E	Prof. Wm. F. Nickersham.
2	14	E	E	E	Rev. W. W. Deatrick, A.M.
7	14	SW	SW	SW	C. M. Thomas, B.S.
0	19	W	W	W	Nathan Moore.
0	18	W	W	W	Prof. John A. Robb.
..	....	....	....	....	Robert M. Graham.
8	19	SW	W	W	J. & B. H. Metcalf.
1	15	N	W	W	J. E. Pague.
6	17	W	W	W	Frank Ridgway, Sgt. Sig. Corps.
2	18	W	NW	NW	Prof Susan J. Cunningham.
6	21	SW	SW	SW	Peter Wood, Sgt Sig. Corps.
5	11	NW	NW	W	Wm. Hunt.
8	15	....	....	....	Miss Mary A. Ricker.
0	13	N	N	NW	Thomas F. Sloan.
..	....	....	....	....	Capt. W. C. Kimber.
8	11	W	W	W	Prof. W. J. Swigart.
6	15	E	W	NW	J. E. Rooney.
9	18	NW	W	NW	Prof. S. C. Schmucker.
0	18	NW	NW	NW	Lewis T. Lampe.
8	18	NW	W	NW	Wm. T. Butz.
2	17	W	W	W	Wm. [illegible] Kline.
..	....	....	....	....	Geo. W. Bowman, A.M., Ph.D
6	17	SE	SE	NE	M. H. Boye.
..	....	....	....	....	John C. Wuchter.
..	....	....	....	....	H. D. Miller, M.D.
1	20	NE	NE	NE	A. W Betterly.
.	....	....	....	....	John S. Gibson, P. M.
6	23	SE	....	N	Prof. S. H. Miller.
..	....	....	....	....	Culbertson & Lantz.
5	14	W	W	W	Charles Moore, D.D.S.
3	13	W	W	W	Lerch & Rice.
3	20	NW	NW	NW	Luther M. Dey, Sgt. Sig. Corps.
4	16	NW	NW	W	E. C Wagner.
12	16	NW	NW	NW	J. M. Boyer,
9	21	NW	NW	NW	W. M. Schrock.
6	20	SW	SW	SW	E. S. Chase.
6	22	NW	NW	NW	H. D. Deming.
12	13	W	W	W	F. O. Whitman.
9	20	SW	SW	SW	Wm. Loveland.
..	....	....	....	....	A. L. Runion, M.D.
9	18	NW	NW	NW	Theodore Day.
..	....	....	....	....	John Torrey.
9	15	....	....	....	J. T. Ambrose.
8	19	NW	NW	NW	Benj. M. Hall.
4	18	NW	NW	NW	Mrs. L. H. Grenewald.

T. F. Townsend, *Sergeant Signal Corps, Assistant.*

Aurora.—Le Roy, 17th; Coatesville, 17th; Grampian Hills, 17th, 18th; Wilkes-Barre, 3d; Nisbet, 17th; Eagles Mere, 5th, 17th.

Coronæ.—Myerstown, 1st; Dyberry, 18th, 22d, 25th.

Solar Halos.—Le Roy, 16th, 18th, 22d; Lock Haven, 22d; Philadelphia, 10th, 22d; Eagles Mere, 9th, 16th, 22d; Wellsboro, 14th, 23d, 30th; Dyberry, 16th.

Lunar Halos.—Le Roy, 22d; Phœnixville, 22d; Rimersburg, 20th, 25th; Meadville, 1st, 21st; Coopersburg, 22d; Eagles Mere, 22d; Dyberry, 22d.

Meteors.—Le Roy, 17th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for October, 1890:

Weather, 78 per cent.
Temperature, 87 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.
Steward M. Dreher,	Stroudsburg.
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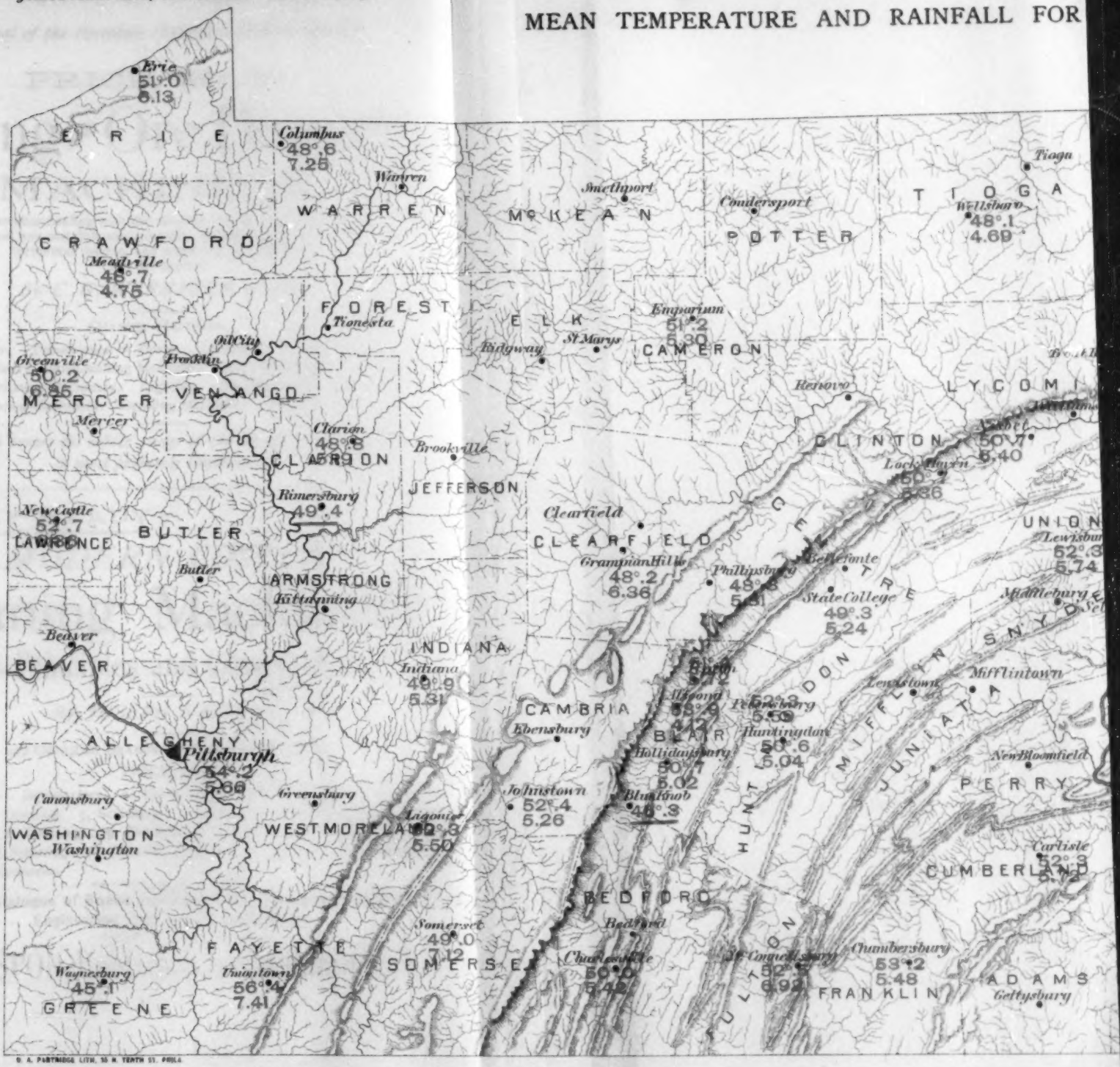

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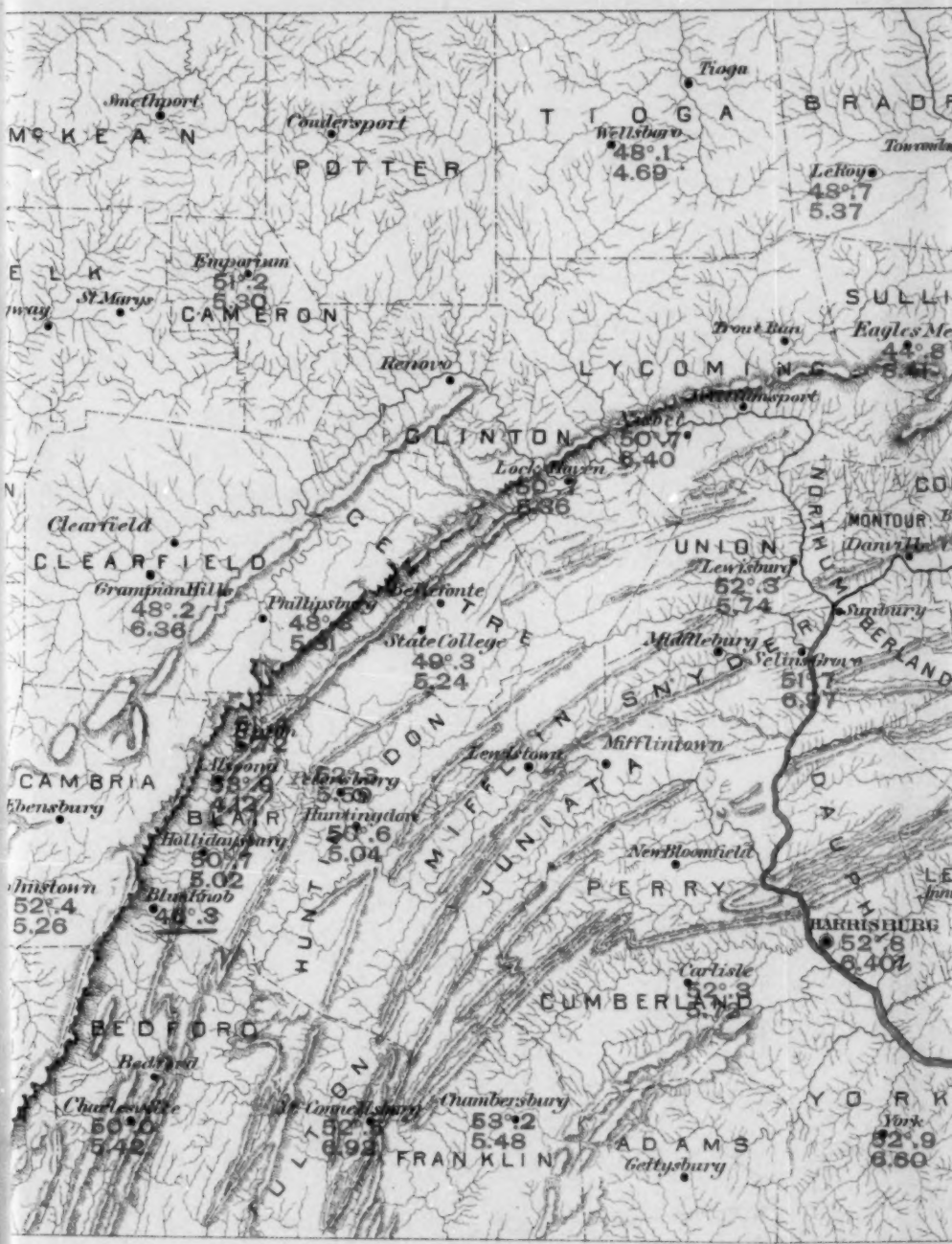

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6.10
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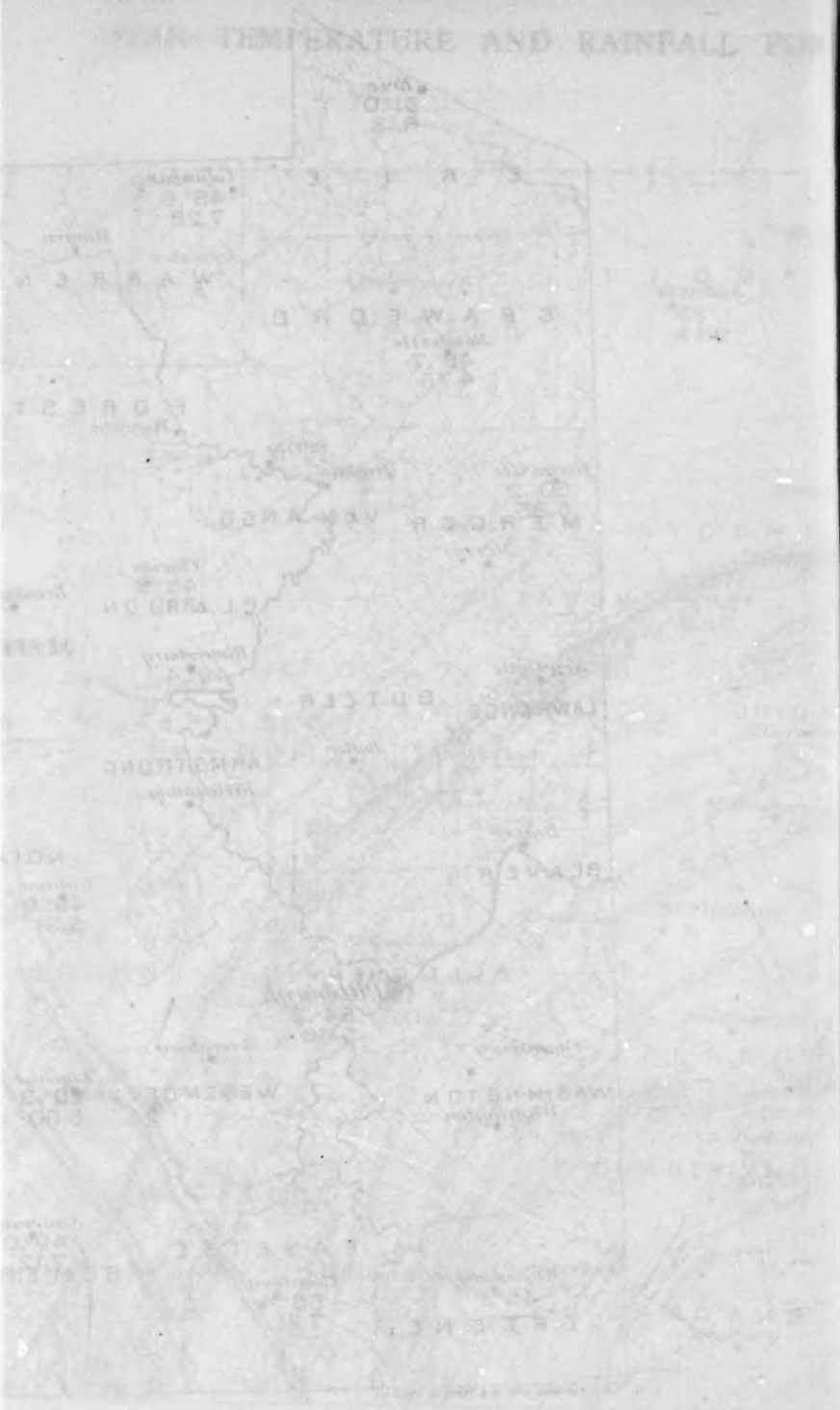

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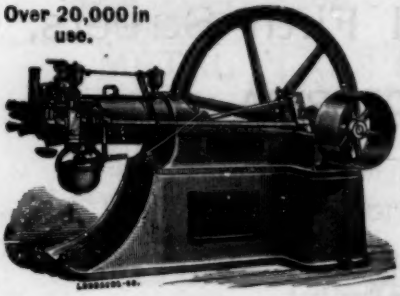

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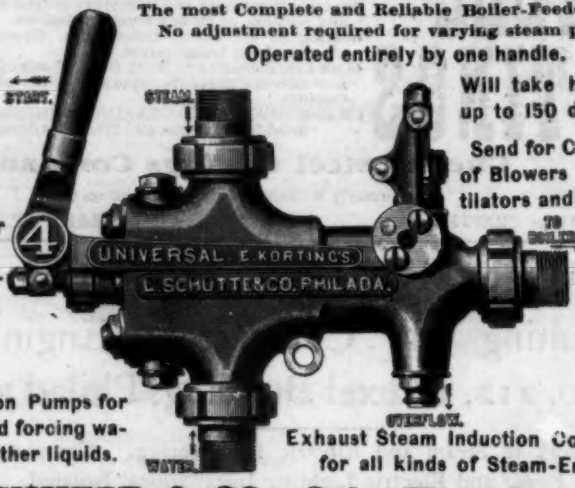

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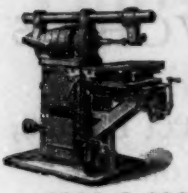

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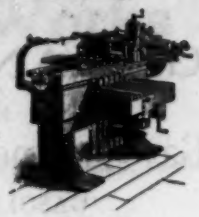

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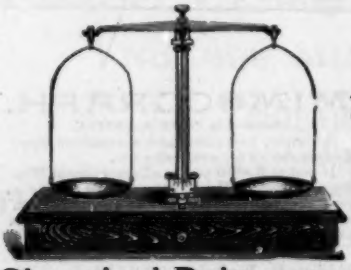

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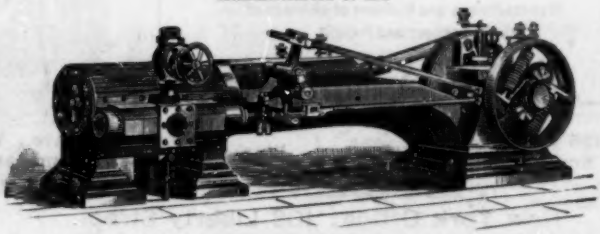

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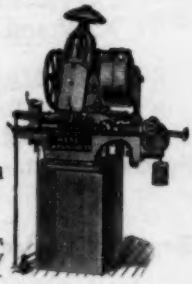

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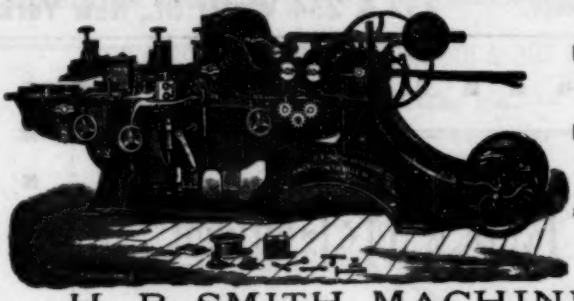

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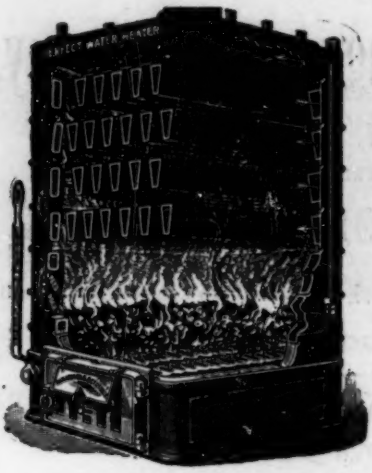

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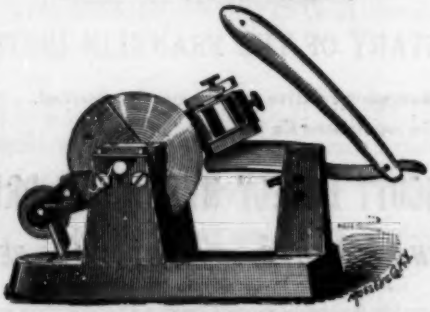

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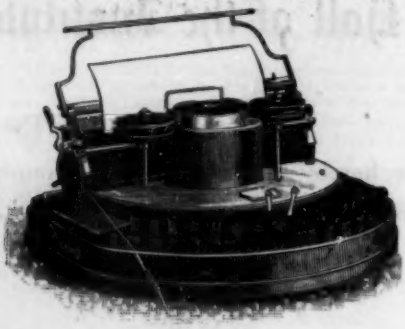

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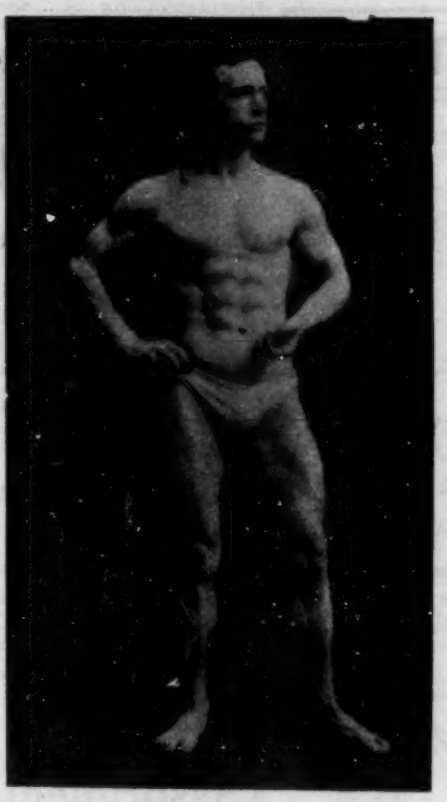

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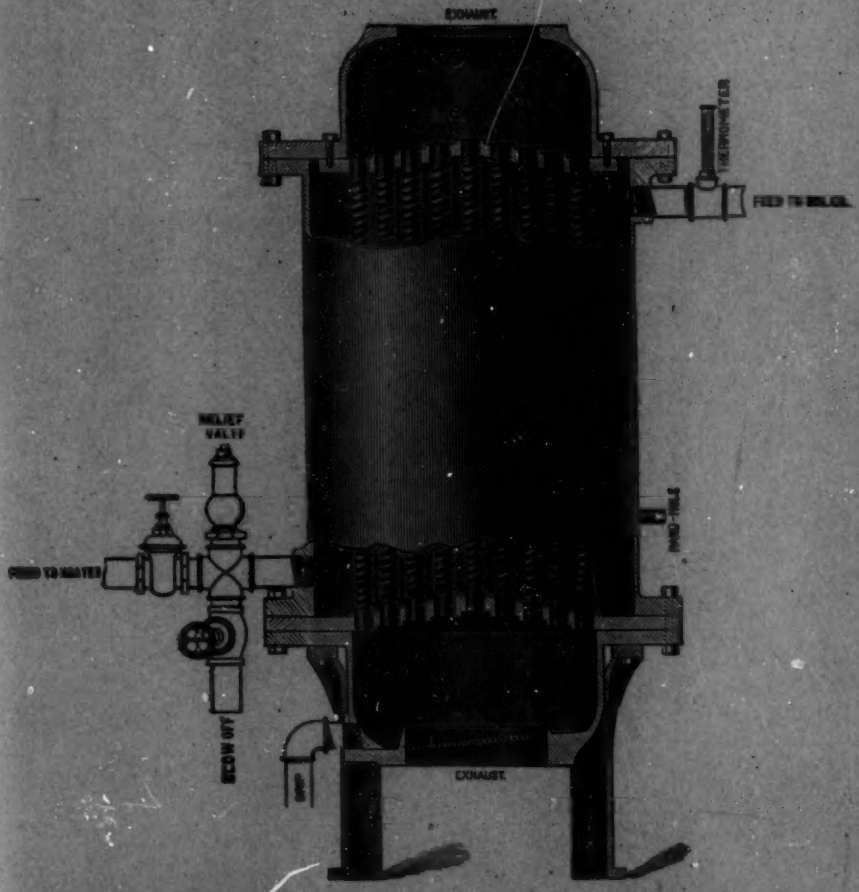

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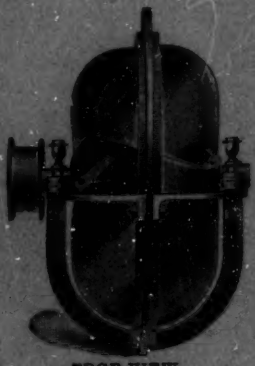

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